SCIENCE

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FRIDAY, AUGUST 1, 1902.

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*THE PREVENTION OF THE POLLUTION OF STREAMS BY MODERN METHODS OF SEWAGE TREATMENT.**

Mr. President, Ladies and Gentlemen:

When the Council of the American Association for the Advancement of Science first asked me to address you on the subject of modern methods of sewage disposal, I felt that it was not a subject of sufficient general interest, and it was only after serious consideration and many misgivings that I consented to do so.

The pollution of streams by the discharge of crude sewage has, however, now reached such a point in the more thickly settled portions of our country, that public attention has at last been called to the subject, and very many of our inland cities are now finding themselves face to face with the problem: How can sewage be treated so that it can be emptied into a stream without causing offense? Such being the case, it may not after all be out of place at a meeting of an Association for the Advancement of Science, to consider very briefly what science has done and is doing towards solution of the problem.

Sewage can be defined as the water supply of a city after it has been used. It contains the solid and liquid excreta of the

* Complimentary address to the citizens of Pittsburgh. American Association for the Advancement of Science, Pittsburgh Meeting, June 28 to July 3, 1902.

population, household waste, the washings of the streets, and the refuse of every branch of industry. The total amount of this refuse matter varies, but on the average the sewage of a city is pure water containing one tenth of one per cent. of city waste; seven pounds in 1,000 gallons. In addition to this refuse matter, sewage contains in immense numbers, approximately 150 millions to the liquid ounce, those microscopic organisms called bacteria, and in the perfect treatment of sewage the bacteria as well as the refuse matter must be removed.

The perfect treatment of sewage, the removal of the microorganisms as well as the polluting substances, *i. e.*, changing sewage back again into a water supply, is possible, but at the present time not practicable on account of cost, and all that so far has been attempted has been to remove the polluting substances of city waste, so that after treatment the sewage will not be offensive to the sense of either sight or smell and when emptied into a stream can cause no offense.

The earliest method of sewage treatment, which, in fact, was not treatment but merely disposal, was to carry the waste products of a community into the ocean or into the nearest stream. This method, known as dilution, is allowable for cities situated on the sea, or on rivers whose flow is very large as compared to the sewage, 100 to 1, and the unfiltered water of which is not used as a water supply.

Very few cities are so fortunately situated as to make use of this method, and for most cities the treatment or purification of sewage must be considered as imperative as the obtaining of pure water. How can this be accomplished? How can the polluting substances be best removed so that the sewage after treatment can, without causing offense, be emptied into a small stream? This is one of the great sanitary problems of the day, and I shall try to give you this evening an outline of the six principal processes by which the necessary purification is to a greater or less degree accomplished.

These methods in historical order are: Sewage farming, chemical precipitation, intermittent filtration, contact bed treatment, septic tank treatment, continuous filtration.

Sewage farming is applying the sewage to cultivated land. Chemical precipitation is the adding of certain chemicals to the sewage to remove or throw down the polluting substances. The four remaining methods, intermittent filtration, contact bed treatment, septic tank treatment and continuous filtration, the so-called modern methods, are all based on the fact that the microorganisms or bacteria always present in sewage will, under proper conditions, destroy all the obnoxious substances contained in sewage.

The earliest method of sewage disposal, as I have already said, was to run the waste products of the community into the nearest river or stream. In a sparsely settled region this caused little complaint; but as the district became inhabited and the towns and villages upon the stream increased in size, it became apparent that this method, though removing the filth from one's own door, would endanger the health and comfort of a large part of the community. It was then that the question of sewage treatment became the subject of scientific inquiry. Without going into any detail as to the early work done upon the subject, I will only state that it resulted in the general adoption of either sewage farming or chemical precipitation as the best means of destroying the polluting substances contained in sewage.

Sewage Farming.—This method was based on the idea that plant life was capable, in itself, of decomposing the complex matters contained in sewage, and that its capacity to do this work was almost with-

out limit; consequently it was thought that sewage could be applied continuously to cultivated land, and, if vegetation was not drowned out, not only would perfect purification take place, but an immense profit could be derived from making use of the polluting substances for plant food. So firmly were these ideas, especially the manurial value of sewage, implanted in the English mind, that the most marvelous undertakings were planned, and to-day at Barking one sees a tunnel which was started to carry the sewage of London one hundred miles into the interior, with the idea that the tunnel should be tapped at certain intervals and the sewage sold, at I know not what price per thousand gallons, to fertilize the land. This is hardly less startling than the idea of recovering the gold that is in sea water.

It is now well known that plant life cannot assimilate the organic matter that occurs in sewage unless it is first decomposed by bacteria, and sewage farming has resulted in failure except in those few cases where the land was of an exceptional character and of very large area, compared to the population to be served, as one acre to fifty persons. The Paris sewage farms, of which we have all heard so much, are far from being a success.

Chemical Precipitation.—The chemical treatment of sewage consists in the adding of certain chemicals, usually lime and iron sulphate, to crude sewage, allowing the sewage to run into large open tanks, through which it flows with such slow velocity that the substances which have been thrown down by the chemicals subside, leaving the supernatant liquid clear and free from all suspended matter, but containing practically all of the soluble putrefying substances that were in the sewage.

Chemical treatment of sewage is costly, averaging between forty and fifty cents per year per head of the population, and the amount of organic matter removed is only about 55 per cent. of the total organic matter in the sewage. The effluent will putrefy, and consequently cannot be emptied into a stream where the dry weather flow is less than ten times the volume of the sewage. The precipitate thrown down is difficult to treat, and if it cannot be carried out to sea and dumped, as is the case of London and Manchester, it must be pressed, and then either carted away to some unoccupied and valueless land, or be burnt. Large plants still exist, however, for treating sewage chemically, the largest of all being the London disposal works, where 183 million gallons are treated chemically each day. The plant at Worcester, Massachusetts, the largest in this country, treats about fifteen million gallons per day. A few pictures of various parts of this plant may show you that treating chemically fifteen million gallons of sewage a day is a serious undertaking.

Sewage farming and chemical treatment are now considered as methods of the past, and all the modern methods of treatment are the so-called bacterial methods.

Intermittent Filtration.—The first of these methods was intermittent filtration. As early as 1865 Dr. Alexander Müller, of Berlin, showed that by passing sewage intermittently through sand, the obnoxious substances were removed, but the explanation of why the sewage could be thus purified is of much later date. It is now known that fresh sewage contains, in immense numbers, bacteria which live on dead organic matter and which cause its decomposition. These bacteria can be roughly divided into two great groups, each containing numerous species. These groups are called the anaerobic and the aerobic groups. The anaerobic group embraces all those species that live, grow and multiply out of contact with air and light; the aero-

bic, those species that live, grow and multiply only in contact with air. Each group plays its own special part in the destruction of the effete matter contained in household waste. The anaerobic bacteria act first. They disintegrate the solid animal and vegetable matters, liquefy them, and bring them into solution. The aerobic bacteria act upon the disintegrated and liquefied compounds and, by a process of oxidation, change them into harmless gases or mineral substances.

For the destruction of dead organic matter both groups of bacteria are necessary; the anaerobic to disintegrate and liquefy the complex organic substances, the aerobic to change those simplified and liquefied compounds into harmless products.

By passing sewage intermittently through sand, conditions favorable to the growth, retention and action of bacteria are brought about, and the obnoxious substances are destroyed by the aid of these microscopic organisms.

The credit of showing that sewage could be purified on a practical scale by intermittent filtration through sand is due to the Massachusetts State Board of Health.

Their experiments, published in 1890, showed that all that was necessary to destroy organic matter in sewage was to provide conditions favorable to the action of bacteria. These conditions they found were fulfilled by providing suitable material on which the microorganisms could be retained; surrounding these microorganisms at certain intervals with air, and providing periods during which they could rest. A suitable material was sand, from four to five feet in depth, and the surrounding the bacteria with air at definite intervals, and allowing periods of rest, was accomplished by underdraining the sand and by allowing the sewage to flow on the sand only six hours out of each twenty-four. The combination of these conditions gave us the process called intermittent filtration.

Plants built to answer the above conditions consist of a number of sand beds, each of about one acre superficial area, carefully leveled, underdrained and divided from each other by dikes varying from three to six feet in height. Crude sewage, after passing through a grit chamber and screens to remove road washings and large floating substances, as rags and sticks, is run successively upon the various beds, none of the beds receiving sewage for a longer period than six hours out of each twenty-four, for if the beds received the sewage continuously there would be absolutely no air present at any time in the bed, and air, as we have seen, is necessary for the life of the aerobic bacteria. By applying the sewage only six hours out of the twenty-four, as the liquid drains out of the bed, air enters to take its place, and the conditions favorable to the action of both anaerobes and aerobes are maintained.

By this process from 50 to 75,000 gallons of domestic sewage, sewage not containing a large proportion of manufacturing waste, can be purified each day on one acre of sand bed area, so that the polluting substances are to such an extent removed that the liquid, as it runs away from the bed, is clear, bright, almost odorless, and can be emptied into a very small stream without fear of causing trouble.

Intermittent filtration is undoubtedly the best method that is known for the purification of sewage of cities and towns which have in their neighborhood comparatively large areas of sandy soil, but is not applicable for cities or towns which would be obliged to construct beds with sand brought from any distance. This point was quickly perceived in England, where sand is not of common occurrence, and the bacterial sewage work in England started with the problem, Can the amount of land re-

quired by the intermittent filtration method be so reduced that the construction of artificial bacteria beds will be a practical possibility?

The results of the investigations started by this problem seem to show that by allotting distinct abodes to the anaerobic and aerobic bacteria, the work of purification can be more rapidly carried on. The abode allotted to the anaerobic bacteria is called the septic tank, that allotted to the aerobic bacteria, contact beds or continuous filters.

The Septic Tank.—The septic tank, about which we have all heard so much, is only a modified cesspool, and the changes brought about in the septic tank are only the changes that occurred in the old-fashioned cesspool of our forefathers, and it is most interesting, as well as somewhat amusing, to see how the old-fashioned cesspool, which only a few years ago was regarded as a breeder of all manner of ills, is now regarded by sanitarians as a most valuable adjunct in the disposal of filth.

A septic tank is only an open or closed tank through which the sewage is run continuously, but at so slow a rate that it requires from twelve to twenty-four hours for it to pass through the tank. The sewage itself, as we have seen, contains anaerobic bacteria, and by allowing the sewage to remain in the tank out of contact of air, these bacteria increase immensely in number, and acting upon the solid and liquid substances in the tank, bring about those changes which are grouped under the name of putrefaction. In other words, the sewage is purifying itself, or, as Professor Sedgwick has recently said, we have sewage in the septic tank 'working,' as it were, like apple juice when the latter is being fermented in a cask by wild yeasts. In cider-making, sweet apple juice, charged with microorganisms derived from the dust on the skin of the apples, or from the atmosphere, or from the sides of the cask, is slowly worked over by these organisms and turned into hard cider and eventually into vinegar. In a similar way, the sewage in a septic tank, charged with anaerobic bacteria, is worked over, or fermented, by these bacteria, which in this way remove or completely change a large amount of the polluting substances, and give a product which is no longer crude sewage, but a sewage in which a large amount of the solid matter has been liquefied or changed into gas.

The change which sewage undergoes in this fermentation process is very marked.

The carbohydrates, substances like starch, sugar, wood fiber, paper, are broken down into simpler substances and partially liquefied; the nitrogenous substances, the so-called proteids, are liquefied, much in the same way that the albumen of the egg is changed when an egg goes bad; and the fats, though not so quickly acted upon, are also partially decomposed. In this process, as in all processes of fermentation, gases are evolved, and the amount given off when the process is in the most active state is not small, equaling about one cubic foot for every hundred gallons of sewage passed through the tank.

The appearance of a septic tank in action is very interesting. The liquid in the tank is very dark and opaque, the surface being, as a rule, coated over with a thick layer or crust of solid matter, through which thousands of bubbles of gas are escaping, and the energy of the action that is taking place in the tank is shown by the continual rising of large fragments of the solid matter from the bottom of the tank, and sometimes with such force that they break through the crust. The gas which these masses contain escapes and they sink again to the bottom of the tank. The rising and sinking of solid matter, with the escape of gas, give almost a boiling appearance to the tank in hot summer

weather. The gas which escapes from the liquid, when closed tanks are used, is conducted off, and, containing large amounts of marsh gas, often 76 per cent., can be used in the same way as natural gas for a fuel or for an illuminant.

This self purification of sewage accomplishes almost as much as chemical treatment, removing about 50 per cent. of the putrescible substances contained in the sewage, and besides saving the cost of the chemicals used in the chemical process, leaves very much less solid matter in the tank to be removed and pressed. The odor, however, from the liquid that leaves the septic tank is often most disagreeable, differing in this way from the liquid from chemical treatment, and with a sewage containing certain kinds of manufacturing wastes, as large amounts of free acid, 20 to 25 parts in 100,000 parts, or other substances which act as germicides, the septic tank can not be used.

The great practical value of the septic tank is that—removing, as it does, half of the impurities—it reduces the amount of sand area required for the purification of sewage. By the intermittent filtration process, where the anaerobic and the aerobic bacteria are working side by side, only 50,000 to 75,000 gallons can be treated per day on one acre of sand area; by the use of a septic tank, which is providing a separate work-house for the anaerobes, about five times as much sewage can be treated on the same area. Further, the septic tank has made the English method of contact beds possible.

The value of the septic tank is now fully recognized and the process is used not only in England, but in many places in this country, and a few of the photographs I have taken I will have thrown on the screen.

Contact Bed Treatment.—This method is the result of experiments made by W. J. Dibden on London sewage. It differs from intermittent filtration in that the sewage instead of being applied slowly and allowed to drain through a bed of sand, is run rapidly into a water-tight bed, filled with a coarse material as cinders, coke or broken stone, and retained in the bed for a given number of hours, after which the liquid is quickly run out of the bed.

An English contact bed is a water-tight bed, one fourth to one half an acre in area, three to four feet deep, thoroughly drained, and filled with almost any hard, jagged material, as burnt clay, coke, cinders, stone, broken to a size that will be rejected by a quarter-inch mesh, but that will just pass through a half-inch mesh. In most places the beds are built on two levels, so that if sufficient purification is not accomplished by the first bed, the liquid from that bed can be run upon a second bed at a lower level. Such a plant is called a double contact system.

This process is not adapted for treating crude sewage, as the action of the bed is intended to be very aerobic and the method of working the process is to fill the bed as quickly as possible, usually in one half hour, with septic tank or chemically treated sewage, allowing the bed to remain full of liquid for two or three hours, and then by opening valves in the drainage system, to empty the bed, in about the same time as was required for filling.

The same bed can be used only twice, or at most three times, in twenty-four hours, and to keep it in good condition it must be allowed to remain idle one day in seven. Working in this way, about 500,000 gallons of sewage can be purified on one acre of contact beds per day, which is certainly over five times the quantity that can be purified by the intermittent filtration process.

The action of a contact bed depends on the presence of aerobic bacteria. If the filling material of a contact bed in active

condition be examined, every individual piece is seen to be coated over with a slimy growth, which if removed and dried cuts like a jelly. Under the microscope the slime is found to be chiefly composed of bacteria.

It is on the presence of this slimy material that the action of the bed depends; the greater in amount, up to a certain limit, the greater the efficiency. If, however, this limit is over-reached, the void spaces between the particles of the filling material become filled up and the liquid capacity is so diminished that the bed becomes spongy and will not allow the water to drain away.

Can this growth of organisms be regulated so that the bed will do its proper work and at the same time not lose its liquid capacity? Further, is serious trouble to be apprehended from the deposition of the non-putrescible part or ash of organic substances?

These are the two points about which there is a great difference of opinion among English sanitary engineers. Many believe from the results obtained at Manchester that the growth of organisms can be regulated and that no serious trouble will be caused by the ash of organic substances. Others, being influenced by the experiments at Leeds, take the opposite view and believe that the loss of liquid capacity depends as much on the retention of the ash of organic substances similar to the humus of the soil, as to the growth of organisms, and that consequently the loss in liquid capacity, or the clogging up of the beds, cannot be prevented no matter how carefully the process is worked. They regard this as so serious a matter as to prevent the contact method from being a practical process with many kinds of sewage, especially those containing iron liquors and acid waste.

My own opinion, after careful study of the whole question, is that crude sewage cannot be successfully treated by the contact-bed method, and should never be attempted, that clarified sewage, sewage from which the solid matter has been removed by chemicals, or sewage which has undergone fermentation in the septic tank, can be successfully purified on contact beds, and that with such sewage the contact method offers a solution to the problem of sewage purification for towns or cities where large areas of sand do not occur. It is not, however, a process which can be run successfully without care and attention, and to be successful requires, as does a slow sand-water filtration plant, the personal oversight of a well-trained sanitary chemist or engineer.

A very large contact bed plant for treating 15,000,000 gallons of sewage per day, costing about $1,500,000, is now being built at Manchester, England, and a few pictures showing the construction of these beds, as well as pictures of some plants in operation, may be of interest.

Continuous Filtration.—With the diversity of opinion regarding the practical success of the contact method of treatment, there has arisen in England during the past two years a growing interest in the so-called continuous filtration methods and the one question you are sure to be asked in England is, 'What is your opinion regarding continuous filtration of sewage?' Continuous filtration is an attempt to still further increase the amount of sewage that can be treated on a given area, to treat two to three million gallons in place of 500,000 gallons per acre per day.

The methods by which this is attempted are all based on the idea that if air is supplied to the filter at the same time that the sewage is being run upon the filter, and the filter is of such a construction and so drained that fresh air continuously remains in the filter, there is no necessity for

periods of rest as required by the intermittent and contact-bed methods, as the only object of periods of rest in these methods is to supply sufficient air to the bacteria.

The continuous supply of air and the continuous retention of air in the filter, the advocates of continuous filters claim can be accomplished by applying the clarified sewage in the form of fine spray, so that each drop of liquid will be surrounded by air as it enters the filter, and that air can be retained in the filter by making the filter of so open a construction and so thoroughly underdrained that the liquid cannot fill up the void spaces between the particles of the filling material.

There is much to be said in favor of these ideas, for there seems to be no reason why if air is always present the bacteria should not act continuously and thus purify a much greater amount of sewage than is possible in those methods where sewage is only run on the filter six or seven hours each day.

Theoretically it would not seem difficult to construct a filter answering the conditions required. Practically, however, it is just otherwise. It has been found no easy problem to devise automatic apparatus to convert successfully large volumes of sewage into the form of spray, or to build filters sufficiently open to ensure air always being present, and at the same time to contain sufficient filling material so that the sewage will be retained in the filter the length of time required for the bacteria to remove the organic matter. The continuous filters now being tried in England are attempts to solve this problem.

Such filters are the Scott-Moncrieff, the Ducat, the Whittaker & Bryant, the Stoddart, and what may be called the Salford filter. Of these filters I consider the Whittaker-Bryant, the Stoddart, and the Salford filters as the most important, and these three different continuous filters are the only ones that I shall at the present time try to describe. They are all merely different methods of applying septic tank or chemically treated sewage in the form of spray to a filter bed of very open construction.

The Whittaker & Bryant filter is a circular or polygonal chamber, about sixty-one feet in diameter and nine feet high, containing a central air shaft. The bottom is made of cement with a collecting drain running along one diameter, connecting with which are tile drains set herring-bone-wise. The pigeon-hole walls of the chamber and air shaft are supported on short brick columns, so that there is an air space between the walls and the concrete floor. The filling material between the outside walls and the air shaft consists of coke one and one half inches or over in diameter.

The sewage is distributed on the surface of the filter by an automatic sprinkler, into the delivery pipe of which is placed a steam pipe, so that a small jet of steam can be blown into the sewage just before it is distributed on the filter in order to raise the temperature of the sewage to about 70°. The heat, according to Mr. Whittaker, 'not only keeps the bacteria at their fullest activity, but raises the temperature of the air in the filter, thereby causing it to rise through the filter, and fresh air to enter, rendering the filter self-ventilating and self-aerating.'

A filter like the one described is calculated to treat sewage at the rate of over one million gallons per acre per day.

The largest Whittaker & Bryant plant is at Church, near Accrington. A very interesting small plant has been erected at Hyde, and is being tested by Mr. Scudder, of the Mersey and Irewell Commission.

The Whittaker & Bryant filter does treat satisfactorily a very large amount of sewage on a given area, at least one million gallons per acre. It removes the putres-

cible substances from the sewage and gives a product that can be emptied into a stream without causing offense. On the other hand, the construction is costly. There is much difficulty experienced in automatically converting the liquid into spray, chiefly through clogging of the holes in the distributer, and being obliged to heat the sewage in winter, which must be done, makes the cost of treatment very large.

A form of continuous filter that has attracted much attention in England during the past year is the Stoddart filter.

This is essentially only a heap of coarse coke or hard cinder, diameter two to three inches, placed on a cement floor which has a fall of one inch in three feet from the center to the collecting drains which surround, but are entirely outside, the filter. As no liquid can remain in the filter no walls are necessary and the side of the filter can be made of large pieces of the filling material, with a slight batten to increase solidity. The essential points of the filter are the slope of floor, the collecting drains and the coarseness of the filling material, free from all small particles.

The method of distribution is patented by Mr. Stoddart, and is one of the most essential parts of the filter. In principle it is very simple. It is made of zinc or galvanized iron, and consists of a number of perforated gutters, eleven in each section, two inches wide and one and a half inches deep, arranged at right angles to the supply channel. The perforations are cut in diamond shape at intervals along the upper edges of the gutters. On the under surface of the gutters are a number of small points, 360 to the square yard. The distributer rests upon the margin of the supply channel and upon suitable supports at the further end, and must be perfectly level to secure equal distribution. The clarified sewage flows from the supply channel into the gutters and over the gutters through the diamond-shaped perforations, and falls from the small points in a series of drops.

A filter such as described, and six feet deep, Mr. Stoddart claims will treat septic tank or clarified sewage at the very high rate of five million gallons per acre.

A number of small plants have been built at different places in England, and experimental plants are now being tried at Manchester and Leeds. Opinions differ greatly as to the amount of purification that can be obtained by this form of continuous filter when run at the high rate of five million gallons per acre. I think, however, it is true that when the filter is in perfect running order, this method will purify sewage at a higher rate than any form of filter yet devised. The trouble is to keep the filter in perfect running order; if any solid matter lodges in the channels of the trays, or if the trays are not kept perfectly level, the distribution becomes uneven, and the successful working of the process depends on the even distribution of the sewage on the filter. To keep the channels free from sediment, and the plates from buckling, even if this is possible, must require constant attention. Further, in this process, there is no provision for heating the sewage in winter, and, in my opinion, in cold weather the whole filter would become one mass of ice, practically stopping bacterial action.

By far the most interesting experiment on continuous filtration that is now being tried is the one at Salford, Eng. In this city a plant has been just constructed by Mr. Jos. Corbett, Borough Engineer, which is to treat from eight to sixteen million gallons of crude sewage per day. The sewage is first to be subjected to chemical treatment, to remove the suspended matter, and the clarified sewage is to be distributed continuously, in the form of spray on the filter bed.

This bed is 500 feet long, 510 feet wide, 10 feet deep, and filled with cinders passed

by one half-inch and rejected by eighth-inch mesh. The method of the distribution of the sewage is novel; the chemically treated sewage runs into two delivery mains, each thirty inches in diameter, one of these connected with seven horizontal pipes, the other with eight. These pipes run the whole length of the bed, dividing it into sixteen sections, and the flow in each pipe is controlled by a valve. From each of these fifteen pipes are raised vertical pipes ten feet apart and ten feet high. Each of these stand pipes is connected at right angles with four-inch horizontal pipes which run across the bed. On the top of the bed, therefore, there is a layer of horizontal pipes ten feet apart. These horizontal pipes are fitted with vertical spray jets at every five feet, each spray pipe having two quarter-inch holes set at an angle.

The floor of the filter has a fall of two feet from inlet to outlet, and is covered with tiles raised on feet sufficiently high, about three inches, to ensure air circulation beneath the filter. The drains are underneath the fifteen large horizontal pipes at the bottom of the chamber and all discharge into a main culvert which carries the effluent into the river.

The chemically treated sewage passes from the valve chambers into one or both of the delivery mains and is delivered to any or all of the horizontal pipes; from these it passes up the vertical pipes into the four-inch horizontal pipes, and then into the spray pipes. There is a sufficient head to cause the liquid to spout out of the spray pipes to a height of from five to eight feet, and it will then fall like rain on the surface of the filter.

The dry weather flow upon the bed is to be about two and one half million gallons per acre, to be increased when necessary to five million gallons.

There is no question but that the construction of this plant is costly, but it seems to me that the chances of successful treatment are greater with Mr. Corbett's plant than by any other method of continuous filtration.

Undoubtedly, continuous filtration has certain merits, especially that of being able to treat larger quantities of clarified sewage on a given area than any other bacterial process, but even if it accomplishes all that is claimed, it is a process that requires a great deal of oversight and attention. Further, I do not see how any of these filters can give satisfactory results in very cold weather unless the sewage is artificially heated, owing to openness of construction, and applying the sewage as spray.

In conclusion I would say regarding the present status of the sewage problem: That Sewage Farming as a general method of sewage treatment is not practicable and seldom possible. That Chemical Treatment only removes a part of the polluting substances in the sewage. It is a partial or preliminary treatment, advisable only in cases where sewage contains germicidal substances, preventing the use of the septic tank. That Intermittent Filtration is the best method for the treatment of sewage of cities where sand can be easily and cheaply obtained, though the amount of sewage that can be treated per acre per day is not over 75,000 gallons, unless the septic tank is used in connection with the process. That the septic tank process is a most valuable adjunct and almost an essential part to all bacterial methods of sewage treatment.

That the contact method is not adapted and should not be used for the treatment of crude sewage, but can be considered a very satisfactory method for the treatment of sewage after it has undergone putrefaction in the septic tank.

That continuous filtration, though capable of treating much greater quantities of sewage per acre than can be done by any

other method, is still in the experimental stage.

LEONARD P. KINNICUTT.
WORCESTER POLYTECHNIC INSTITUTE.

PHYSICS AT THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION.

THE meetings of Section B were held in the Middle Lecture Room of the Carnegie Institute. The first session of the Section on Monday, June 30, at 2:30 P.M., was taken up with the address of the retiring Vice-President, Professor D. B. Brace, on the subject 'The Group-Velocity and the Wave-Velocity of Light.' Tuesday afternoon the Section adjourned to inspect the Westinghouse works at East Pittsburgh. Wednesday morning was devoted to a joint session with the American Physical Society and Thursday noon the Section took a final adjournment for the Pittsburgh meeting.

The Section program was an unusually full one. Its forty-five titles, together with the fourteen on the program of the American Physical Society in joint session with Section B, may be roughly classified as follows: 23 were in the domain of electricity and magnetism, 22 in optics, 7 in thermodynamics, 4 in general mechanics and 3 in acoustics. The titles and a number of abstracts of the papers presented are given below. The papers were presented by the writers, except as otherwise indicated.

Contributions to the Theory of Concentration Cells: HENRY S. CARHART, University of Michigan.

The paper dealt first with concentration cells of the first class, in which two electrodes of one metal are immersed in a solution of a salt of the same metal, the density of the solution being different at the two electrodes. The Nernst theory requires that the direction of the E.M.F. within the cell be from the dilute to the concentrated solution. The author has discovered a cell in which the E.M.F. is directed the other way, viz., from the concentrated to the dilute solution. It consists of nickel electrodes immersed in solutions of nickel sulphate or nickel chloride.

The explanation given depended on the thermal E.M.F.'s at the two electrodes. Curves were exhibited showing that these E.M.F.'s increase with the density of the solution. In most concentration cells the thermal E.M.F. is from the metal to the solution; in nickel cells it is in the other direction. Hence the reverse direction of the E.M.F. of these cells. Application was made of these new facts to the explanation of the dependency of the E.M.F. of the Daniell cell on the density of the two solutions, and to the reversal of the temperature coefficient of the Daniell cell when the density of the zinc sulphate solution is only slightly over unity.

The paper next took up the other class of concentration cells in which the two electrodes are amalgams of a metal of different densities, the two amalgams being immersed in a single solution of the same metal. In these the thermal E.M.F.'s *increase* when the density of the amalgams *decreases*. The direction of the E.M.F. within the cell from the concentrated to the dilute amalgam is thus explained.

Further, since the thermal E.M.F. increases with the density of the solution, and decreases with the density of the amalgam, it should be possible to make a concentration cell with the denser amalgam in the denser solution and the weaker amalgam in the weaker solution, so that the E.M.F. of the cell would be zero. This has been found to be true.

Curves of thermal E.M.F. were shown for amalgams of different densities.

A preliminary paper will be published in the *Proceedings of the American Electrochemical Society*.

On the Complex Product of E.M.F., Current and other Vectors: H. T. Eddy, University of Minnesota.

The rules which govern multiplication and the other processes of ordinary algebra are those of mere number in its arithmetical sense. But algebra necessarily admits the use of complex numbers, to which arithmetical processes, such as multiplication, are perfectly applicable. Such complex numbers used as factors are not physical vectors, though they are frequently represented geometrically as quasi vectors.

When a physical vector, such as a force or a velocity, expressed in complex notation is multiplied by a mere numerical complex, the ordinary rules of algebra still hold. But when we multiply together two physical vectors expressed in complex form in order to obtain their product, the result has a physical significance which imposes laws of operation differing from those of ordinary algebra, and the factors are found to be non-commutative. The paper contains a detailed comparison of the nature of the two kinds of complex products, especially directed to the consideration of the product of pairs of alternating vectors of the same frequency, to show that the double frequency of such products does not arise in any way from the non-commutative character of the multiplication, as has been sometimes assumed.

Coefficients of Expansion between 0° and —190° C.: J. S. Shearer, Cornell University.

The coefficients of expansion for a number of metals at low temperatures have been measured by Dewar, using the method of weighing in liquid air. The writer has tried to get a method for the determination of the linear coefficients between 0° and —190° C. The method finally adopted was based on the idea of the compensated pendulum. By means of a combination of iron and cadmium, one end of the specimen was held fixed, while the other operated an optical lever.

This paper will later be published in full in the *Physical Review*.

A Set of Direct Current Dynamos arranged in Series for High Tension Work: G. S. Moler, Cornell University.

This paper describes, in detail, the installation at Cornell University of 24 small 500-volt dynamos connected in series. The machines are separately excited and give 0.22 ampère of current under an E.M.F. of 12,000 volts. This paper will later be published in full elsewhere.

Test of Liquid Air Plant at Cornell University: Frank Allen, Cornell University.

This plant consists of an electric motor, a compressor and a liquefier.

The compressor is of the four-stage type with air cylinders of about seven-, four-, two-, and one-inch diameter and of eight-inch stroke. Purified air is compressed by this machine to a pressure of 2,700 pounds per square inch.

In order to accomplish this a 500-volt electric motor of 30 horse-power is used, which has an efficiency of 87.6 per cent.

The apparatus used for liquefying air is known as the Hampson Liquefier, from the name of its English inventor. It works on the principle discovered by Lord Kelvin many years ago, that gases expanding from a high pressure to a low become slightly cooled. Air compressed to 2,700 pounds is allowed to flow through coils of copper tubing and issues at a low pressure from a small valve. The cool air circulates among the coils and cools the incoming air, which in its turn expands, lowering its temperature still more. This process goes on continuously and in about five minutes the

air is cooled enough to liquefy. The liquid air is collected in double-walled glass vessels with a vacuum between the walls.

In this test the power supplied during an hour was accurately measured, as was also the amount of liquid air obtained. By an expenditure of 25 horse power for one hour 2,919 grams of liquid air were produced. That is, the expenditure of one horse power per hour produces 116 grams of liquid air. The low temperature of the liquid air renders a certain amount of heat energy available. To vaporize one gram of the liquid requires 50 calories, or heat units. To raise the temperature of the gas from the boiling point of liquid air (—190° C.) to ordinary atmospheric temperature requires 47 calories more. The total amount required per gram is therefore 97 calories. For 116 grams there would be required 11,310 calories, or if the energy is expressed in mechanical units it amounts to 35,000 foot pounds.

In other words, the expenditure of one horse power continuously *for one hour* results in the production of just enough liquid air, which if it were utilized in its turn as a source of power in a *perfect* machine, the greatest amount of power obtainable would be one horse power *for one minute*. The most efficient method of obtaining liquid air as yet discovered, would increase this last period of time to *five minutes!*

The efficiency of the plant discussed in this paper was thus very low, being not quite two per cent.

The Theory of the Electrolytic Rectifier: K. E. GUTHE, University of Michigan.

The paper described the method of investigation and was illustrated by means of curves showing the relation between the current and the reaction, or polarization, or condensation voltage, with different metals and salt solutions.

Rayleigh's Alternate Current Phasemeter: E. S. JOHONNOTT, Rose Polytechnic Institute.

In the *Philosophical Magazine* for May, 1897, Lord Rayleigh has described a 'soft-iron galvanometer' which is quite suitable for measuring all quantities such as are ordinarily measured with ammeters, voltmeters and wattmeters. It consists of a soft-iron needle suspended between two parallel coils at an angle of 45° to their common axis. Besides furnishing a simple means for determining the phase relation in circuits, the instrument may be used as a wattmeter. Breslaurer has recently shown that it has advantages over the electrodynamometer used as a wattmeter on circuits having low power-factors.

Some experiments were undertaken with the instrument to determine the iron losses in choking coils where the power-factor was varied over a wide range by increasing the air-gap in the magnetic circuit.

Ordinarily the connections are similar to those for the wattmeter, the E.M.F. coil being connected across the terminals of the circuit and the other, the current coil, in series with the same. Another manner of using the instrument was found in practice to be much more simple and to give more consistent results. The connections for this method were the same as for Blakesley's split dynamometer. An exploring coil, exactly similar to the magnetizing coil, was wound on the magnetic circuit and connected in series with the E.M.F. coil of the phasemeter.

The instrument is as easily made as any simple form of galvanometer. The laws which connect the readings with the electrical quantities are perfectly similar to those of other alternate current instruments.

Many laboratory exercises, such as the determination of coefficients of self induc-

tion, phase angles and power, may be undertaken by the student with ease.

Measurement of the Intensity and Pressure of Radiant Energy: E. F. Nichols and G. F. Hull, Dartmouth College. Presented by Professor Hull.

This paper was supplementary to a paper on the same subject which was read at the Denver meeting of the American Association for the Advancement of Science in August, 1901. In the earlier paper it was shown that the 'gas action' due to a beam of light falling on a torsion radiometer had been approximately eliminated and that the 'light pressure' had been measured to the same degree of approximation; but that in the comparison of the experimental value of the light pressure with that deduced from the Maxwell-Bartoli formula, using the value of the energy as measured, a discrepancy of about twenty per cent. was found.

An analysis of the earlier work showed an error in the energy measurement due to an error in the resistance of the bolometer used. A new value of this resistance was found by the potentiometer method and by the application of theory to the determination of the resistance of a circular disc. The new value of the energy gave an agreement between the Maxwell-Bartoli formula and experiment, to about five per cent.

Later a more satisfactory method of measuring the energy was used, in which was observed the change of temperature of two thermojunctions of fine iron and constantin wire, placed inside a small silver disc upon which the radiation fell. The thermoelement was calibrated by immersing the silver disc in baths of kerosene at different temperatures. The average error in the measurement of the energy was considered to be less than one per cent.

By analysis of the earlier data on light pressure it was shown that the gas action had been eliminated approximately from the ballistic values, but was present in the statical readings. Later and more accurate experiments confirmed this result. The new value of the radiation pressure was found to agree with that derived from the Maxwell-Bartoli formula, using the new energy determination, to within a few per cent. For greater accuracy it will be necessary to measure the absorption and reflection coefficients of the surfaces used.

On the Penetration of Light into the Rarer Medium in the Case of Total Reflection: E. E. Hall, Cornell University. Read by title.

This paper will appear later in the *Physical Review.*

An Improved Form of Torsion Radiometer: E. F. Nichols, Dartmouth College.

A new radiometer case, somewhat larger than that of similar instruments earlier described, was shown. The advantage of the new form lies wholly in the support carrying the suspension, which is so designed that the length of the quartz fiber may be easily changed and the sensitiveness and period of the instrument altered through a wide range. All adjustments may be made without removing the suspension from the case, so that the danger of breaking the fiber is reduced to a minimum.

The Optical Properties of Iodine: W. W. Coblentz, Cornell University. Read by title.

The paper will appear in the *Physical Review.*

The Emission of a Righi Vibrator and the Measurement of the Length of Electric Waves by the Interferometer: H. R. Willard and L. E. Woodman, Dartmouth College. Presented by E. F. Nichols.

The paper dealt with the radiations emitted from a Righi vibrator which were studied in the first instance by resonance

effects on a Klemenčic receiver, the length of which was varied. The curves bring out the existence of two upper partial vibrations or overtones; in some cases the third overtone also appears. The wave-length of the fundamental was later measured by the interferometer method. Further work on the same subject is in progress.

Some Experiments on Retinal Fatigue and Persistence of Vision: FRANK ALLEN, Cornell University.

The experiments were a continuation of some discussed in the *Physical Review*, Vol. XI., 1900, p. 257. It is a matter of common observation that when a person is some time in the dark the retina suffers 'adaptation,' which enables faint light to be more readily perceived. Some experiments were performed by the Nichols method of the measurement of the persistence of vision, to see how adaptation progressed with time. A normal measurement of the persistence of vision was made with the eye in its ordinary condition of adaptation for diffused daylight. Measurements were made after darkness adaptation of one-, three-, five-, ten- and fifteen-minute intervals. The results, when plotted with time intervals as abscissas and increases of persistence of vision as ordinates, give a curve much like a magnetic saturation curve. The measurements for fifteen minutes are practically the same as for five with all colors. Adaptation seems to be quite complete in five minutes. Longer intervals than fifteen minutes were not tried.

Experiments were next made in the same way by fatiguing the eye with light of various wave-lengths. Observations were made on the same wave-lengths as the fatiguing colors. The zero of reference was the normal persistence of vision with different colors; 'saturation' curves were obtained exactly as described above, the maximum fatigue being realized in three minutes with all colors.

The maxima of the curves differ, however. For wave-length .675μ the maximum is represented by 14. For yellow (.589μ) fatiguing has no effect. For green (.523μ) the maximum is 10. For blue (.470μ) no change of persistence occurs under the fatiguing stimulus of even ten minutes' exposure to the blue of an arc spectrum. In the violet (.430μ) the maximum is 20. These maxima, when plotted with wave-lengths as abscissas, give three elevations corresponding suggestively with red, green and violet.

The persistence of vision on the temporal side of the retina, ten and twenty degrees distant from the center, was measured. Throughout the spectrum the persistence diminished the further out the measurements were made. Some peculiarities were noticed in the part of the curve corresponding to the yellow region of the spectrum, connected doubtless with the 'yellow spot.'

The complete paper will appear in the *Physical Review*.

A Radiometric Receiver for Electric Waves: G. F. HULL, Dartmouth College.

The form of receiver for electric waves generally used in quantitative work is the Klemenčic thermoelement. Here the dissipation of the energy into heat at the contact of two wires joining the two halves of the resonator gives rise to an electromotive force which causes a deflection of the galvanometer. In the form of receiver described in this paper this heat is made evident by the radiometric action on a very small vane of a torsion balance. Among the various receivers used the one so far giving the best results consists of two silvered strips of mica of the proper length for the waves used. These are divided at their centers by a very fine diamond scratch and are mounted vertically with

the center of each strip opposite a small vane. The whole system is placed in a bell-jar in such a way that the strips are in the focus of a parabolic mirror. The deflections are read by a telescope and scale. Owing to the lightness of the moving system (about 6.5 mgs.) and the efficiency of the method, the sensitiveness can be made much greater than that of the receivers of the Klemenčic design.

On the Efficiency of Window Illuminating Prisms: D. C. Miller, Case School of Applied Science.

The paper gave the results of photometric investigation of the distribution of light by prisms of various shapes, placed in different positions and operating with various sky conditions. The results are shown by distribution diagrams, from which are drawn conclusions as to the relative efficiencies under given conditions.

A Portable Photometer for Measuring Light Distribution: D. C. Miller, Case School of Applied Science.

The arrangement described is a special form of photometer which may be moved in any way, as about a pivot, for quickly measuring with moderate accuracy the relative intensity of light sent out in any direction from a source.

A Lummer-Brodhun screen is used to compare the light from the source with that from a standard illumination, the latter being capable of measured regulation from zero intensity to the maximum required.

The application of the photometer to the measurement of the distribution of light throughout a room, as by a window prism, was described.

Models for Explaining Polarized Light: D. C. Miller, Case School of Applied Science.

A description (with exhibit) was given of a series of original models for explaining double refraction, action of one Nicol prism and of two Nicols forming a polariscope; also for explaining the production of interference colors by a thin plate of a doubly refracting substance placed between crossed polarizer and analyzer.

A Model for Showing the Superposition of Two Oppositely Moving Wave-trains: W. S. Franklin, Lehigh University.

This model is designed for class-room demonstration and it consists of a large number of horizontal bars. One set of ends of these bars rests upon a wave-template and the other set of ends rests upon another wave-template. These two templates move in opposite directions at the same velocity. The middle points of the horizontal bars communicate to a row of points or balls the resultant motion of the two wave-trains.

The Just-Intonation Pianoforte of Dr. S. A. Hageman: H. T. Eddy, University of Minnesota.

Dr. Hageman has invented and constructed a pianoforte which will render the diatonic scale in perfectly just intonation in any key that may be desired. The piano differs in outward appearance from the ordinary piano simply in the fact that there is, in addition to the usual pedals, a bank of a single octave of pedals somewhat like organ pedals. These pedals actuate a bank of sliding bars on the back of the piano, which, in turn, move the bridges on which the piano strings rest, and adjust them simultaneously to any key desired by thus altering their effective lengths. It is believed that this cheap and exceedingly simple but perfectly effective device is the first practical solution of the problem of just intonation for instruments with fixed keys. The device is applicable to other instruments with fixed keys.

The piano is tuned in the usual manner in equal temperament and may be played in equal temperament also if so desired.

Contributions to the History of Musical Scales: CHAS. K. WEAD, Washington, D. C.

This paper was a summary of a research just published in the 'Report of the U. S. National Museum' for 1900. It described some forms of four-hole resonators found in various museums that give a pentatonic scale, whose notes have vibration frequencies following a square-root law; and various flutes and fretted string instruments were cited that show an equal linear division. The conclusion was that the primary principle of instruments capable of giving a scale is the repetition of elements similar to the eye; so the instrument is the first thing, the scale a secondary thing. Theoretic scales belong to a much later stage of culture.

The Present Significance of Enharmonic Musical Instruments: CHAS. K. WEAD, Washington, D. C.

These instruments may, in the hands of an artist, furnish a new point of view from which to judge of the development of music and its possibilities. But there is no evidence that any important music was ever composed in just intonation or that any of the many proposed or patented instruments are fitted to express the ideas of a composer. Certainly the diatonic idea which underlies such instruments is now far less important than when Helmholtz wrote, forty years ago.

Preliminary Note on the Effect of Percussion in Increasing Magnetic Intensity: GEO. F. STRADLING, Philadelphia.

When a rod of iron, steel or nickel has been magnetized and then demagnetized by the passage of a current of proper strength through the coil in which the rod is placed, tapping the rod causes the appearance of poles having the same direction as those existing before demagnetization. These poles, as the tapping continues, grow in strength to a maximum and then decrease.

If the demagnetizing current more than overcomes the original magnetism and produces poles in the opposite direction, still the effect of tapping is to make them first approach to those originally existing and then recede. In this case there are three stages produced by percussion:

1. Lessening of pole strength to zero.
2. Growth of pole strength in the direction existing before demagnetization.
3. Decrease of the strength of these newly acquired poles.

Whether percussion increases or decreases pole strength depends on the previous magnetic history of the body examined.

Preliminary Note on the Electrical Conduction of Saturated Powders: N. E. DORSEY, Annapolis Junction, Md.

The electrical conductivity of non-conducting powders saturated with electrolytic solutions was compared with the conductivity of the supernatant liquor. For coarse-grained powders the two are proportional, but when the powder is fine the conductivity of the saturated powder at first increases more rapidly than that of the supernatant liquor, with the result that for quite dilute solutions the conductivity of the saturated powder, as measured in a cubical cell, a pair of whose opposite sides served as electrodes, may even exceed that of a volume of the supernatant liquor equal to that of the solution in the powder as measured in the same cell.

Determination of the Vapor-pressure of Mercury at Ordinary Temperatures: EDWARD W. MORLEY, Cleveland, Ohio.

The writer has determined the vapor-pressure of mercury at intervals of ten de-

grees from 20° to 70°. A quantity of mercury was kept at a constant temperature, while a known volume of an inert gas was passed through in such a way as to become saturated with the vapor of mercury. From the loss of weight of the mercury, and the volume of the gas when at the temperature of the mercury can be computed the weight of vapor in unit volume, and the vapor-pressure.

Carbon dioxide was freed from accompanying hydrochloric acid by passing through sodium acid carbonate, and dried by phosphorus pentoxide. The mercury was contained in a spiral absorption apparatus. By a somewhat elaborate apparatus, a hundred liters of water were kept at a temperature constant within two or three hundredths of a degree. In an air-bath in this water were placed two absorption apparatus containing mercury. In one, gas passed at a rate of about thirty liters in a day, while the current was a third more rapid in the other. As both rates gave the same final values, it was thought that in both the gas had been saturated. The observed loss was always made as much as about ten milligrams; at the lower temperatures this required some twenty days.

Van der Plaats, in 1886, made determinations at 0°, 10° and 20°. About the same time the writer made determinations at 15°. All the observations, whether recent or older, are represented by the interpolation formula

$$\text{Briggs Log } P = -4 + 0.6020 + 0.02718\,T,$$

which gives the pressure in millimeters of mercury. The greatest difference between observation and formula is 0.0008 mm. and the mean difference is 0.00025 mm. The extrapolation formula of Hertz agrees with observed values at 20°, but is in excess by thirty per cent. at the higher temperatures; the formula of Ramsay and Young agrees with observation nearly as well.

On the Feasibility of Transmuting Terrestrial Heat into Available Energy: Jacob Wainwright, Chicago.

This paper has been published privately by the author.

On the Conditions Controlling the Drop of Potential at the Electrodes in the Vacuum Tube Discharge: C. A. Skinner, University of Nebraska.

The paper was presented by Professor Zeleny and will later be published in the *Philosophical Magazine.*

The drop of potential at the electrodes is supposed to be due to the difficulty of the carriers to give up their charges to the metal on account of the velocity of impact.

This velocity must first be reduced, which is done by repeated bounding away from the electrode, the coefficient of restitution being taken as less than one. An equation was obtained for an ideal simplified case for the time required for the carrier to be brought to rest. The longer this time, the greater is the fall at the electrode on account of the accumulation of the carriers at the surface.

Experiments in which some of the quantities involved were varied gave results in harmony with the above view of the cause of the drop at the electrodes.

On the Rotary Dispersion of Fuchsine Solutions: F. J. Bates, University of Nebraska. Read by title.

Sparking Potentials for Small Distances: E. Earhart, Rose Polytechnic Institute. Read by title.

On the Magnetic Behavior of Nickel-copper and Nickel-tin Alloys: Bruce V. Hill, University of Nebraska. Read by title.

Some Observations Showing the Oscillatory Character of Lightning: A. W. Smith, University of Mississippi. Read by title.

On the Effect of Electrolytic Condensers in Alternating Current Circuits: A. TROWBRIDGE and E. R. WOLCOTT, University of Wisconsin.

The paper was presented by Professor K. E. Guthe and described in detail phenomena observed in electrolytic condensers used in alternating-current circuits. It was shown that the custom of regarding such condensers as two ordinary condensers in series was erroneous, as such a view is inadequate to account for the enormous capacities observed. The paper will be published in full elsewhere.

On the Accuracy of the Zero in a Dynamophone: J. BURKITT WEBB, Stevens Institute of Technology.

Presented by Professor B. F. Thomas.

The dynamophone is a new dynamometer in which the energy transmitted per revolution is measured by the twist of the shaft transmitting it, said twist being measured while the shaft is in motion by an electrical method in which no contact is made with the shaft.

It consists of two armatures or toothed wheels mounted on the shaft at a sufficient distance from each other, each wheel having a telephone magnet with its coil mounted in front of it in such a way that it can be revolved about the shaft. The distance of the telephone magnets from the armatures is also adjustable. These two telephones are connected in series with a receiving telephone which, when the two telephones are properly adjusted to opposite phases and equal amplitudes, gives no sound or indicates *zero*. When the shaft twists under the transmission of a moment the observing telephone must be revolved through the angle of twist to obtain the *zero* or opposition of phase.

As in some cases the observing magnet can be revolved through a small angle without perceptibly altering the zero, it is advisable to discuss the accuracy of the same, regarded as a question of the interference of waves of the same period with slightly different overtones, and to use a method of observation which avoids the difficulty to a great extent.

Absorption of Salts in Aqueous Solutions by Powdered Quartz: LYMAN J. BRIGGS, Washington, D. C.

Finely divided quartz when shaken up with an aqueous solution of a salt possesses the property of increasing the concentration of the solution in the region immediately outside of the solid particle, thus decreasing the concentration of the free solution. Quantitative results showing the relation between concentration and amount of absorption have been obtained for carbonates, hydroxides and chlorides of sodium, potassium and ammonium.

(*a*) The absorption of the acid radical was found to be independent of the base.

(*b*) The amount of absorption is not a linear function of the concentration, but is relatively greater for dilute solutions.

On the Osmotic Pressure of Absorbed Salts: LYMAN J. BRIGGS, Washington, D. C.

Osmotic pressure of absorbed salts must be the same as in the free portion of the liquid, if equilibrium exists. But the concentration of the absorbed layer is greater than in the free solution. Therefore, the osmotic pressure of the absorbed layer is not proportional to the concentration of that part of the solution.

On the Rapid Filtration of Turbid Solutions and the Change in Concentration Produced by the Porous Septum: LYMAN J. BRIGGS, Washington, D. C.

This paper, which will appear in Bull. 19, Bureau of Soils, U. S. Department of Agriculture, was read by title.

On the Formation of Dew Bows: Lyman J. Briggs, Washington, D. C.

A description was given of the formation of a prismatic bow caused by the reflection and refraction of light from drops of dew supported on extremely fine spears of grass.

Note on a New Form of Laboratory Switchboard Jack: F. C. Caldwell, University of Ohio.

This form of jack, which has proved very successful, is made up of one or more brass tubes with a shoulder at one end and threaded at the other, so that an ordinary nut screwed on will hold the jack in the board. Where opportunity for inserting two or more plugs is required, these jack tubes are united by yokes on the back of the board. Ten of these jacks after several months' use averaged six-thousandths-volt drop when carrying 100 ampères. The plug for this jack is a straight piece of three-eighths-inch rod slit at the end and fastened in a handle. The cost of such a single jack with nut, washer and plug complete is trifling.

Note on a New Variable Ironless Induction Coil for Large Currents: F. C. Caldwell, University of Ohio.

This coil is interesting because of its large size. It is made up of two concentric coils, one swinging within the other. Its resistance is 1.4 ohms, and its impedance, with sixty period current, about forty ohms. It is wound with ten layers of twenty turns of No. 8 wire in the outside coil, and nine layers of twenty turns in the inside layer. About one hundred pounds of wire was used in the construction. The outside diameter of inside coil is twenty inches.

On Molecular Friction in Steel and Phosphor-Bronze: J. O. Reed, University of Michigan.

The method consisted in observing the time required for a tuning fork to diminish its amplitude of vibration from one fixed amplitude to another, the tuning fork being enclosed in a chamber heated electrically, and the amplitudes being observed by a telescope. This period of time becomes a minimum at about 70°C. and then increases again. The diminution in amplitude was assumed to be due chiefly to molecular friction.

Young's Modulus for Phosphor-Bronze, Between 20° and 300° C.: J. O. Reed, University of Michigan.

The phosphor-bronze was in the form of the tuning fork of the last paper and it was heated in the same chamber. The paper described the additional appliances necessary to measure Young's modulus. The results obtained were given.

A Photographic Study of the Alternating Arc: G. A. Hoadley, Swarthmore College.

An alternating arc was observed under the following conditions: (*a*) Between carbon points, ordinary; (*b*) between carbon and zinc points, showing that there is an illuminating arc only once per cycle, and that there is a direct current passing from zinc to carbon in the arc, which can be read by a direct-current ammeter; (*c*) between carbon points in a magnetic field showing the alternating direction of the current; (*d*) between carbon points, the lower of which is double, showing that two direct-current ammeters placed in the lower branches will show two direct currents if placed in opposite directions.

The Nernst Lamp: A. J. Wurts, Pittsburgh, Pa.

Mr. Wurts gave a very interesting account of the technical evolution of the Nernst lamp in this country, mentioning many of the defects in the original which had been overcome by the ingenuity of American engineers. The lamp in its pres-

ent form was exhibited and the functions of its various parts explained.

Absorption Spectra of the Permanganates: B. E. MOORE, University of Nebraska. Read by title.

The Index of Refraction and the Absorption of Fuchsine: W. B. CARTMEL, University of Nebraska. Read by title.

Determination of Dispersion by Means of Channeled Spectra: S. R. WILLIAMS, University of Nebraska. Read by title.

E. F. NICHOLS,
Secretary Section B.

SECTION B.

IN SESSION WITH THE AMERICAN PHYSICAL SOCIETY.

The meeting was held in the Middle Lecture Room of the Carnegie Institute, July 2, 1902. Professor W. Le Conte Stevens was elected chairman *pro tem.* The program follows:

Results of Recent Magnetic Investigations: L. A. BAUER, U. S. Coast and Geodetic Survey, Washington, D. C.

The paper was illustrated by charts which exhibited the results of recent researches in terrestrial magnetism conducted by the U. S. Coast and Geodetic Survey. Several recording magnetic instruments of modern construction were described and methods of standardization discussed. Lantern slides of the new magnetic observatories of the survey were shown.

Some Recent Interesting Magnetic Disturbances Registered at the Coast and Geodetic Survey, Magnetic Observatories: L. A. BAUER.

The records of a number of recent magnetic disturbances taken at the different magnetic observatories of the Coast Survey were shown by lantern slides and the significance of the results obtained was discussed. Both of the foregoing papers will appear in the *Journal of Terrestrial Magnetism and Atmospheric Electricity.*

On the Relation between Thermoelectric Power and Change of Length, caused by Magnetization: EDWARD RHODES, Haverford College.

A thermoelectric pile of fourteen iron wires, 40 cm. long, thirteen copper wires, 15 cm. long, and one bar of a special alloy of antimony and zinc, was built up. The alloy has the property that its thermoelectromotive force with iron is such as to counteract that of the thirteen copper iron junctions.

When this pile has steam and cold water jackets placed over its ends and is inserted in a suitable solenoid, a curve may be obtained showing the thermoelectric power, at the mean temperature, of magnetized, against unmagnetized iron, as the field is varied.

A cyclic curve of this kind was taken and proved to be of the peculiar and distinctive type of the cyclic change of length curves.

In order that the two curves should agree, however, it is necessary to correct the change of length curve for the contraction $B^2/4\pi Y$, where Y is Young's modulus.

A similar thermopile was constructed of nickel wires. In this case only the first ascending branch of the curve was taken. This was of the same type as the change of length curve for nickel, which is altogether different from that for iron.

The existence of this relation seems to open the way to a large amount of further work on the nature of magnetism.

The complete paper will appear in the *Physical Review.*

Experiments on the Electrolysis of Radioactive Solutions: GEO. G. PEGRAM, Columbia University. Read by title.

Absorption Spectrum of Carbon: E. L. Nichols and E. Blaker, Cornell University. Presented by Dr. Blaker.

The selective radiation of carbon has already been shown. A further series of experiments have been made during the past year on the selective absorption of carbon. Deposits have been obtained by deposition on glass in vacuum tubes between terminals of carbon, in series with the secondary of an induction coil, the residual gas being acetylene. These deposits vary in composition without doubt, and show different absorption for different conditions of deposition, depending on the pressure of the residual gas.

Deposits made on platinum by 'flashing,' as in the ordinary incandescent lamp, and then transferred to glass and studied with the spectrophotometer, show the same peculiarities as have been shown to be obtained using glowing treated carbon. The dispersion has not been fully studied yet.

The paper will be published in the *Physical Review.*

Persistence of Vision in Color-blind Subjects: Frank Allen, Cornell University.

In this investigation, color-blind subjects were studied by the Nichols method of the measurement of the persistence of visual impressions. A sectored disc was rotated in front of the slit of a spectrometer at such a speed that the flickering of the part of the spectrum under observation just became imperceptible. The speed at this instant was electrically recorded on a piece of paper carried on a chronograph cylinder.

The measurements when plotted as ordinates with wave-lengths as abscissas form a 'persistency curve' which is parabolic in shape, convex toward the axis of abscissas, and with the apex at the *D* line. Under the same conditions of brightness of the spectrum and adaptation of the retina the persistency curve is invariable for the same subject and even for persons of about the same age, providing their color vision is normal. Color-blind persons obtain persistency curves which usually coincide with normal curves in part, but which always have one or two elevations. The positions of these characteristic elevations afford a means of classification; for they occur only in the parts of the curve corresponding to the red, green and violet of the spectrum.

The Young-Helmholtz theory postulates three fundamental color sensations—red, green and violet. In color-blind subjects it may be expected that any one of these may be absent or modified alone, or that any *two* may be absent or modified, or that all three may be absent. The last phenomenon is that of total color-blindness, and its existence is not provided for by the Young-Helmholtz theory, apart from total blindness. There are thus seven possible types of color-blindness, and in this investigation persistency curves corresponding to six of them have been obtained, the missing one being that in which an elevation is to be expected in the violet end of the curve. One case of total color-blindness is also described which is remarkable in that the brightest part of the spectrum is in its normal position to him. No similar case has yet been described.

In this research twenty-six cases of color-blindness were examined, and their results permit a very complete and systematic classification, such as is obtained by no other method. The conclusion reached is that the fundamental sensations are red, green, violet and white. The assumption of more than these three color-sensations is strongly opposed by these experiments.

Heat of Vaporization of Liquid Air: J. S. Shearer, Cornell University.

This paper will appear in the *Physical Review.*

The Magnetic Field Produced by a Flight of Charged Particles: R. W. WOOD and HAROLD PENDER, Johns Hopkins University. Read by title.

Note on the Thermal Unit: H. T. BARNES, McGill University. Read by title.

On the Action of a Condenser in an Induction Coil: J. E. IVES, University of Cincinnati. Read by title.

Note on a Graphical Method for Tracing Rays Through Optical Prisms: WILLIAM FOX, College of the City of New York. Read by title.

On a New Half-shade Polariscope: D. B. BRACE, University of Nebraska.

An Explanation of the Faraday and Zeeman Effects: D. B. BRACE. Read by title.

Additional Notes on the Construction and Use of the Brace Spectrophotometer: S. B. TUCKERMAN, University of Nebraska. Read by title.

E. F. NICHOLS,
Secretary pro tem.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

THE tenth annual meeting of the Society was held at the Carnegie Institute, Pittsburgh, Pa., on June 27 and 28, 1902. The attendance was larger than at any meeting since 1898 and the interest was so well maintained that the attendance at the four sessions did not vary ten per cent. Thirty-four applicants were elected to membership, making the total 287.

At the opening session the members were deeply grieved at the announcement by the President of the sudden death of Professor John Butler Johnson, Dean of the College of Engineering, University of Wisconsin, the notice of which appeared in the Pittsburgh press the evening before. Professor Johnson was one of the founders of the Society, a past president, and its first secretary. His enthusiasm, influence and active work for the Society were prominent factors in its development and usefulness, and he expected to be present at the Pittsburgh meeting, and, as usual, to take part in the discussions.

After the transaction of general business the President, Professor Robert Fletcher, Director of the Thayer School of Civil Engineering, read his address on 'The Efficiency Factor in Engineering Education.' After referring to the object of the Society an analysis of the membership was given which showed that 10 per cent. are practicing engineers who are not teachers, about 18 or 20 per cent. are both teachers and practitioners, 45 to 47 per cent. are teachers only or chiefly in civil, mechanical, electrical, mining and other departments of engineering, about 3 per cent. are identified mainly with instruction in pure technics, such as manual training, etc., while about 21 per cent. give the indispensable and fundamental preparation in mathematics, mechanics and the physical sciences. Another division gives 33 per cent. as committed to civil, 22½ per cent. to mechanical, 11 per cent. to electrical, and 9½ per cent. to mining and other branches of engineering. The balance of 24 per cent. constitute the teachers in preparatory courses and the practicians. An analysis was then made of the character of the 179 papers and reports by members and committees, respectively, which, together with the discussions, are printed in full in the nine volumes of *Proceedings*. Attention was called to the distinction between engineering and technology and the inconsistencies between the titles and performances of many engineering and technical colleges or schools.

The factor of efficiency in engineering education was regarded as influenced and

determined by the purpose in view, the personnel, both of teachers and taught, the substance and methods of instruction, and the machinery and cost. A lack of purpose characterizes too much of the secondary education where education itself is regarded as an end instead of a means, while the extreme type of training is given in the military and naval academies, whose definite aim is to raise up a body of officers fitted to command men. In discussing the time to be devoted to the college and professional courses, the statement was made that the regular college courses are not made effective enough even for culture.

With respect to the personnel of the teachers, it was held that, while a teacher of engineering must be primarily a teacher, he is not simply a pedagogue, but has much in common with the engineer in practice. To be efficient he must give inspiration and direction, and know his students. There must be mutual respect, confidence and sympathy. The element of command should accompany his direction and instruction. The habit of obedience should be formed in the student, for disobedience may be as fatal 'on the works' as in the army. The quality of the student material should be determined not simply by the academic test of the requirements for admission, but also by the test of character. Those who are not found to be entirely trustworthy should be promptly excluded.

As to the substance and methods of instruction the larger and ever-increasing work required of engineering colleges today demands that it be a more powerful agency. The principle of concentration is to be applied, since the range of primary and essential topics is so much greater than formerly that there is no room for non-essentials. The student's tasks should relate chiefly to that which he must learn while a student. The recitation should be used whenever practicable, the lecture method but seldom. What the student really gains comes from his own study of the book or of full notes, and by hard thinking. The coordination of subjects, as to both sequence and quantity, is of equal importance with the principle of concentration. Electives in a well-balanced curriculum should be restricted to a few courses in which the studies are entirely adapted to ends clearly defined. The principle of continuity follows that of coordination, and its application shows that it is a disadvantage to sandwich preparatory and culture studies between engineering studies.

Machinery as related to efficiency in engineering education includes all instruments, apparatus, machines, models, etc. Efficiency is determined by sufficient every-day exercises, with due regard to proper limitations of accuracy. There is not time enough for the student to acquire familiarity and facility with machines beyond those of fundamental utility. In modern engineering operations the principal criterion of efficiency is cost. The annual appropriations for the national military and naval schools represent the interest on a principal far greater than the endowment of any American university. Sufficient endowments to render an institution independent of income from students would limit classes by stricter standards of merit only, and avoid the lessened efficiency implied in large classes with inadequate teaching force. The tendency to expend too much in expensive buildings lessens the funds available to secure the best men as teachers. The principle to govern should be: good men at any price, a good plant at the least cost consistent with utility. The final estimate of the cost goes beyond the outlay of money and cannot be made until the professional development of the graduates is in evidence. Here, as elsewhere, the prime principle of the engineering profession is to derive the largest and best output possi-

ble from the judicious expenditure of money and labor.

The President's address was followed by a very interesting discussion on 'The Value of Non-resident Lectures on Engineering Subjects.' The three written discussions were by Professors William D. Pence, George F. Swain and Robert H. Thurston. In brief, such lectures, as a rule, were regarded as having but little value as a means of education, their chief value being as a means of inspiration and suggestion to the students, and of legitimately advertising the institution; keeping it in touch with the profession and extending its influence. They are also valuable to the local members of the faculty, in giving them additional opportunities to come in contact with engineers in active practice. As so much depends on the personality of the lecturer great care should be exercised in the selection.

At the afternoon session 'Methods of Grading Students in Engineering Colleges' were treated by Professor Charles P. Matthews, the practice of many colleges being given, as obtained by means of a circular letter containing ten questions.

Professor Francis C. Caldwell read a paper on 'Laboratory Notes and Reports,' in which stress was laid upon the necessity of impressing on the student the importance of original notes, and that this depended upon the shape in which they were taken down, and the care used in keeping them neat and clean so as to avoid copying. Attention was called to the danger of too great detail in the nature of printed report blanks, used to supplement the note-books and to make the students familiar with methods of making reports.

In the paper on 'Electrochemistry as an Engineering Course,' Professor Charles F. Burgess referred to the prominence of electrochemistry before the public through its progress along strictly scientific lines, as well as by reason of industrial development, which has been largely independent of the other. This subject may be taught as a science, perhaps included under the broader heading physical chemistry, or it may be taken up as a branch of engineering technology. The justification of establishing engineering courses in applied electrochemistry was considered, and an outline given of the studies that may properly be included in such work.

This paper was followed by an adjourned discussion of Professor Wm. G. Raymond's paper presented at the meeting in 1901, and which advocated some radical changes tending to reduce the course in engineering at least one year. The charge was made that by the present arrangement time was wasted: (1) By too much vacation, (2) by doing class work instead of work with the individual, and (3) by mixing engineering subjects with preparatory and general culture subjects. This discussion was lively and interesting, sixteen members taking part, those of Professors A. N. Talbot and C. L. Mees being written. Professor Talbot maintained that the vacations were educationally valuable to the students, as most of them engage in work of an engineering character, especially after the sophomore year, while others engage in business pursuits; that the instructors and younger professors engage in practice which fits them for better service, while others are making preparation for the following year's college work or in research. He also held that work with the individual was not applicable to information subjects, nor to foundation subjects where the quiz and class discussion secured better results; that where it was useful it was already employed, as in specialized courses, such as the design of structures, machines, etc., and that certain exercises require party work. Continuous work in one subject is in general unpedagogical. It was further claimed

that the segregation of engineering studies has been carried about as far as the condition of the preparatory schools permit, but that, essential as the training in general principles is recognized to be, it is advantageous to give some specialized courses of instruction.

At the Saturday morning session the first paper presented was that of Professor Elwood Mead on 'Courses of Instruction in Irrigation Engineering.' He described the magnitude and complexity of the industrial problems connected with irrigation in the West, and the need of engineers with special training not only to properly design the canals and other works with greater economy than was possible formerly, but also to administer the systems when established. The information upon which both laws and administrative practice must be based must be largely gathered by the engineer. The settlement of the arid region is already creating important problems in statesmanship and economics involving the relations of vested rights and the respective spheres of state and national authority. The State Agricultural College at Colorado was the pioneer in giving special courses of instruction relating to practical irrigation and the attendant business, social and legal problems. The paper gave the irrigation engineering course recently adopted by the University of California, and it was urged that other western colleges might advantageously adopt a similar course in providing for this need.

No abstract can give any adequate idea of the admirable paper as to both contents and style, by Professor Edward Orton, Jr., on 'The Subdivision of the Field of Chemical Engineering Education.' He gave the relative magnitude and increasing importance of the ceramic and cement industries, as well as those depending on metallurgical processes, and stated the need for men who should have a large part of the usual education of an engineer in combination with that of a chemist.

In discussing 'Some Abuses of the Lecture System,' Professor A. W. French gave five strong objections to the use of lectures to any material extent in giving instruction on engineering subjects, considering the present ample supply of text-books adapted to the needs of engineering colleges. The fact that the lecture system furnished the easiest method for the instructor to handle large classes was not regarded as a valid excuse, since it is the duty of large institutions to provide as adequate class instruction as is done by the small ones. It was recommended that in the few cases where lectures are properly used each student should be furnished with a copy or at least with full notes, so that his entire attention may be given to the thought presented in the lecture room.

At the afternoon session Professor C. M. Woodward read a paper on the 'Management of Intercollegiate Athletics,' which described some of the difficulties now encountered, and aimed at developing a higher moral standard in the actual conduct of intercollegiate athletics. A series of rules relating to eligibility of members of teams, etc., was given. A strong conviction was expressed that in some way the evils of gate fees at athletic contests and the large expenditures incident to training tables, extensive trips, etc., should be eliminated. In the discussion which followed a decided protest was raised against the undue encroachment of athletics on the legitimate work of many students who could not afford to make the sacrifice.

'Over-development in Engineering Laboratory Courses' was treated by Professor F. P. Spalding. He stated that the importance of laboratory instruction in all lines of scientific study, and its absolute necessity to any properly organized course in engineering, are generally conceded, but that the

rapid development of such instruction has led to some excessive application. In undergraduate courses the laboratory instruction should be based upon and carefully coordinated with the class room work, and not pursued as an end in itself. The attempt to introduce research work into undergraduate courses may often involve a serious waste of the students' time. With large classes and a scheme fully outlined by the instructor the student may easily fall into habits of careless and superficial reasoning. Really beneficial work of this character is only feasible to a very limited extent, under careful oversight, the student being required to fully discuss the results of his investigations. Objection was made to using a student's time to assist in making commercial tests in place of work in the regular course. The facilities for research presented by large laboratory equipments present an attractive field to graduate students, but immature young graduates should not be allowed to use too large a portion of their time in this manner.

The last subject considered was 'Excessive Differentiation in Engineering Courses.' Written discussions were given by Professors Marburg, Magruder and Allen, while Professor C. M. Woodward and nine others participated in the oral discussion. There was considerable difference of opinion expressed, although in many cases the speaker did not clearly state what was regarded as excessive differentiation. Some believed that a single general course should be given for all engineering students, while others maintained that civil, mechanical, electrical and mining engineers should have courses differing materially in the last two years and which also permit a limited amount of electives in the senior year. The former arrangement is contrary to the entire course of development of engineering education in this country, and it is interesting to notice that at this very meeting of the Society three separate pleas were made for still further differentiation, on the ground that the industrial development of the country demanded it.

Three of the committees of the Society made reports. That on technical books for libraries presented the objects of its work and pointed out some of the ways in which the libraries may assist in the promotion of engineering education. That on entrance requirements related to the formulation of entrance requirements. The committee expected to present a set of formulations to a similar committee of the National Educational Association at its Minneapolis meeting, July 7–11. The Committee on Statistics reported the number of students enrolled during 1901–02 at the different institutions in the different courses; the number of students pursuing engineering courses; the number and kinds of degrees conferred on engineering graduates to date by the different institutions; on the advisability of securing further statistics and the attitude of administrative officers in regard to furnishing the desired information, etc. Professor C. M. Woodward, of Washington University, was elected chairman of the Committee on Industrial Education, on account of the death of Professor Johnson, while Professor A. L. Williston was elected to fill the vacancy in the membership of the committee.

The Society, after considerable discussion and investigation, by a special committee appointed last year, decided at this meeting to appoint a 'Committee on Requirements for Graduation.' The President was authorized to take some time in selecting the members and the committee will be announced in a circular probably in September.

The following are the newly elected officers of the Society:

President, Calvin M. Woodward, Dean of the College of Engineering, Washington University.

Vice-Presidents, John J. Flather, University of Minnesota, and Frederick W. McNair, President of Michigan College of Mines.

Secretary, Clarence A. Waldo, Purdue University.

Treasurer, Arthur N. Talbot, University of Illinois.

Members of Council until 1905: William Esty, Lehigh University; Henry S. Jacoby, Cornell University; Lewis J. Johnson, Harvard University; Ellwood Mead, University of California; Edward Orton, Jr., Ohio State University, and William M. Towle, Syracuse University.

HENRY S. JACOBY,
Secretary (1901–2).

CORNELL UNIVERSITY.

ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

THE fourteenth annual meeting of the Association of Economic Entomologists met in the West Room of the Lecture Hall, Carnegie Institute, Schenley Park, Pittsburgh, Pa., Friday and Saturday, June 27 and 28, 1902. The following papers were presented:

'Some Notes on the Use of Lime Salt and Sulphur and Resin Washes in Ohio': A. F. BURGESS, Columbus, Ohio.

(1) 'Experimental Work in New York State against the San José Scale'; (2) 'Observations on Certain Insects of Pine Trees': E. P. FELT, Albany, N. Y.

'Soluble Arsenic in Arsenical Insecticides': JOHN K. HAYWOOD, Washington, D. C.

'On the Study of Forest Entomology in North America': A. D. HOPKINS, Morgantown, W. Va.

'Recent Work against Shade-tree Insects': A. H. KIRKLAND, Boston, Mass.

(1) 'Résumé of the Search for the Native Home of the San José Scale in Japan and China'; (2) 'Present Status of the Imported Asiatic Lady-Bird Enemy of the San José Scale; its Possible Usefulness with the Native Lady-bird Beetle, *Chilocorus bivulnerus*, and the Natural Enemies, which may Check the Influence of Both Insects': C. L. MARLATT, Washington, D. C.

'Notable Insect Occurrences in Ohio for the First Half of 1902': H. OSBORN, Columbus, Ohio.

(1) 'Report of Experiments with the Lime, Salt and Sulphur Wash against the San José Scale in Maryland'; (2) 'On the Feeding Habits of the Adults of the Periodical Cicada': A. L. QUAINTANCE, College Park, Md.

'Egg-laying Record of Plum Curculio': A. L. QUAINTANCE and R. I. SMITH, College Park, Md.

'Results of some Recent Experiments against the San José Scale in Georgia': W. M. SCOTT, Atlanta, Ga.

'Notes from Delaware': E. DWIGHT SANDERSON, Newark, Delaware.

The following officers were elected for the ensuing year: *President*, Dr. E. P. Felt, Albany, N. Y.; *Vice-President*, Wm. H. Ashmead, Washington, D. C.; *Second Vice-President*, Professor Lawrence Bruner, Lincoln, Neb.; *Secretary and Treasurer*, Professor A. L. Quaintance, College Park, Md.

A. L. QUAINTANCE,
Secretary.

SCIENTIFIC BOOKS.

Ophthalmic Myology, a Systematic Treatise on the Ocular Muscles. By G. C. SAVAGE, M.D. Nashville, Tenn. 1902. Published by the author.

Dr. Savage's book is one that will doubtless gain a wide currency among ophthalmologists. Even those who differ with him the most widely must acknowledge the painstaking care, the thoroughness, the great ingenuity and the perfect sincerity which combine to make his work suggestive and valuable. Moreover, his long and ample experience in this special field gives him a certain right to speak with authority wherever practical questions are involved.

Among those who busy themselves with practical eye work, the book is sure to be widely read and quoted, and its teachings to find extensive, though not universal, acceptance. But for this very reason it becomes all the more necessary for the reviewer to point out what he cannot but regard as essential and considerable errors in the work. And if he confines himself mainly to this more ungracious part of his task, it is because the good qualities of the book speak for themselves and make encomium of them supererogatory.

One of the fundamental notions in Dr. Savage's book and one that affects the reasoning all through it is found in the statement on p. 2:

"With this axis [the visual axis] the four recti muscles are *alone** concerned as to the final result of their action. The superior and inferior recti of the two eyes are required to keep the visual axes always in the same plane. * * * The oblique muscles are required to so relate the vertical antero-posterior planes of the two eyes that the vertical axes which lie in these planes may be parallel with each other, and with the vertical plane of the head." The inference is that the superior and inferior recti are practically the only muscles concerned in elevating and depressing the eyes, and the obliques the only ones that rotate the vertical meridians or keep these meridians vertical. And that this is his view is shown unmistakably by the further statement (p. 4): "Each of the conjugate innervation centers controls *two* muscles, *one for either eye*. The first [serving to elevate both eyes] controls the two superior recti; the second [serving to depress both eyes], the two inferior recti; * * * the sixth [serving to keep the vertical axes from diverging above], the two superior obliques; the seventh [serving to keep the vertical axes from converging above], the two inferior obliques." So also his eighth and ninth centers, which are supposed to keep the vertical axes of both eyes parallel with the median plane of the head in the oblique positions of the gaze, control respectively the right superior and left inferior, and the right inferior and left superior obliques.

Now if there is one fact in regard to the eye-muscles that is demonstrated alike by anatomy, by physiology and by clinical investigations, it is that in elevation of the eye both the superior rectus and the inferior oblique take part, and that about equally, although in the straightforward direction of the gaze the superior rectus is the more efficient of the two. The elevating center, therefore, controls the two inferior obliques quite as much as it does the two superior recti; and the depressing center controls the two superior obliques as well as the two inferior recti. So too both physiological investigations and a study of the results of paralysis show that the inferior and superior recti quite as much as the obliques are concerned in producing torsion of the vertical meridians, and Savage's various centers, by which this torsion is regulated and the vertical meridians kept vertical and parallel, must govern these recti as well as the obliques.

It is but just to say that Dr. Savage himself admits this, at least in part, in speaking of the action of the individual muscles (pp. 39 *et seq.*); and it seems all the more strange that he should not recognize the bearing of this admission upon his theories of the combined actions of these same muscles, produced by the coordinating centers.

The error above noted has an important practical consequence. It leads Dr. Savage to the further erroneous teaching that in the diagnosis of paralysis of the various muscles, it is sufficient to determine the curtailment of rotation or determine the amount of diplopia in the four cardinal directions only (up, down, in and out). This would be so if, as he assumes, the four recti alone acted to carry the eyes in these various directions. If, for example, the inferior rectus was the only muscle that depressed the eye, measurement of the degree of downward rotation would indicate whether the inferior rectus was weak or not. But since the superior oblique takes a very large part in performing this downward rotation, we cannot, from the mere fact that this rotation is limited, infer that the inferior rectus is weak. We can do so only by demonstrating that the limitation of movement increases markedly in looking downward and outward and diminishes to zero in looking downward and inward.

In fact for diagnosticating weakness or paralysis of the individual muscles, we must determine the range of excursion of the eyes or the amount of diplopia in six, not in four, cardinal directions, viz., right, left, up and right, up and left, down and right, down and left. Unless this fact is realized, the diagno-

* Italics mine.

sis of ocular paralysis cannot be made with certainty, and Dr. Savage's differentiation (on pp. 514 and 515) is hence inadequate, and, if strictly adhered to, would often mislead. In particular, it may be said that the tilting of the false image, upon which he relies for his diagnosis, is a very unsafe guide, being often absent and sometimes transferred to the image formed by the non-paralyzed eye. This part of the book, in fact, must be characterized as quite unsatisfactory.

It is not necessarily true, as stated on page 517, that in comitant squint there is no diplopia. In many, indeed in their beginning probably in most, cases of comitant squint there is a diplopia, which, in distinction from that of a paralytic squint, remains the same in all parts of the field.

Objection must also be raised to his statement that in oblique directions of the gaze, the obliques act to keep the vertical meridians of the two eyes not only parallel but also always vertical. This certainly runs counter to a vast mass of anatomical and physiological data accumulated by various observers, and seems to be supported by no direct proof, being based solely on *a priori* reasoning.

The author's well-known views on cyclophoria, its production by oblique astigmatism, and its correction by means of cylinders, are given full place in the book. The reviewer has not seen reason to concur in these views nor to consider cyclophoria as an important element in muscular anomalies.

There are various other points regarding which the reviewer would take issue with the author, such as his notion that in esophoria the presence of a certain amount of hyperopia necessarily argues that a certain proportion of the esophoria is false or accommodative (p. 198); his failure to recognize divergence anomalies; and in general his tendency to attribute muscular anomalies too exclusively to disturbances in the tension and action of the muscles *per se*, rather than to disturbances of the conjugate centers, particularly those for convergence and divergence. We have good reason for thinking that it is in these centers that most motor anomalies arise, so that in their origin at least such anomalies are usually bilateral, affecting the movements of both eyes equally, while the muscles *per se* are normal at the outset, and do not become affected until later on.

Enough has been said, however, in the way of criticism, and it seems fitting to close with a word of hearty praise for the many original ideas that the book contains; for the author's skill in their presentation; for his fairness in dealing with the work of others; and finally for the many happy suggestions that he puts forth, particularly as regards treatment, whether by exercise or by operation.

Alexander Duane.

New York City.

SOCIETIES AND ACADEMIES.

THE TEXAS ACADEMY OF SCIENCE.

At the meeting of the Texas Academy of Science, held in the Chemical Lecture Room of the University of Texas, February 21, 1902, Dr. William Morton Wheeler, Professor of Zoology, presented "A Consideration of S. B. Buckley's 'North American Formicidæ'" (by title), and delivered an illustrated lecture on 'The Principles of Acceleration and Retardation in the Development of Animals.'

At the meeting of April 25, Mr. E. T. Dumble, of Houston, read a paper on the 'Cretaceous and Later Rocks of Presidio and Brewster Counties,' which is of interest on account of the prominence now given the last-named county, owing to the discovery and development of quicksilver deposits in the Terlingua District.

The second paper on the program was presented by Dr. William L. Bray, Professor of Botany in the University, who discussed 'The Present Status of Forestry in Texas.' Many excellent views, illustrative of the subject, were thrown upon the screen.

The formal meeting of the Academy was held in the Chemical Room of the University on Wednesday, June 11, at 3:30 P.M.

President J. C. Nagle announced the result of the election of officers for 1902–1903, which is as follows: *President,* Robert A. Thompson, M.A., C.E., Expert Engineer to the State Railroad Commission; *Vice-Presidents,* Professor O. C. Charlton, M.A., late of

Baylor University, and Professor J. C. Nagle, of the Agricultural and Mechanical College of Texas; *Treasurer,* Dr. H. Y. Benedict, Adjunct Professor of Mathematics and Astronomy in the University of Texas; *Secretary,* Dr. Frederic W. Simonds, Professor of Geology in the University of Texas; *Librarian,* Dr. William L. Bray, Professor of Botany in the University of Texas; *Members of the Council,* Hon. Arthur Lefevre, State Superintendent of Public Instruction, Henry Winston Harper, M.D., F.C.S., Professor of Chemistry, University of Texas, and Dr. William Morton Wheeler, Professor of Zoology in the same institution.

The first paper on the program was on 'Consciousness and Purposive Movements,' by Dr. Edmund Montgomery, of Hempstead, Texas.

Professor S. E. Mezes, of the University, discussed 'Some Fundamental Characteristics of the Extensity of Sensations.' He pointed out that every sensation has a local sign embedded in it, different, roughly speaking, from every other local sign, and that sensations, therefore, constitute, from this point of view, a manifold of differing elements. This manifold is, however, continuous, and not discrete; for any two local signs, *A* and *L*, whose difference is barely discernible, are less similar to each other than either is to other local signs, *e. g., B, C, J, K,* and this is precisely the distinguishing characteristic of a continum. Another very fundamental characteristic of our extensity experience the speaker found in the arrangement of local signs and their sensations in tridimensional extent. The basis of this he found in our organic and muscular sensations coming from within the skin, which are always present as a totality in waking moments, and which in their totality constitute, as immediately felt, a tridimensional bulk. And it is because of their relations to our tridimensional cenesthesia that special sensations are located in tridimensional space. First, largely by virtue of the changing relative positions of different parts of the body, there arises ontogenetically a sense of empty space surrounding the body, and largely because of the contrast of double and single touch there arises a sense of filled space outside the body. Here it was insisted that touch intrinsically locates its objects outside the surfaces of the body, and *in the third* dimension relative to that surface. Moreover, all the special senses, probably in virtue of being daughter senses descended from the mother sense of touch, were found to locate their objects in tridimensional space. Cheseldens and other cases were quoted to show that vision never presents a colored surface only, but at the worst a colored surface located *in the third* dimension, a point that has been strangely overlooked. And with local signs of depth thus present in vision, even under the least favorable conditions, it was considered at least possible that these same local signs were competent, when developed by practice, to substitute objects in proper perspective for the surface seen antecedent to practice.

Professor H. Ness, of the Chair of Botany in the Agricultural and Mechanical College of Texas, spoke on 'De Vries' Mutation Theory,' which has recently attracted widespread attention.

Mr. W. H. von Streeruwitz, of Houston, a former geologist on the State Geological Survey, who had recently returned from a protracted visit abroad, spoke upon 'Mining—With some Account of Russian Practice.'

The last paper was of a very practical character, being an exposition of 'New Departures in Cotton Mill Machinery and Appliances,' by Messrs. Stonewall Tompkins and W. E. Anderson, Mechanical Engineers of Houston.

Part II., completing Volume IV. of the *Transactions* of the Academy, has been received from the printer and is now being distributed. The following is the table of contents: 'The Influence of Applied Science,' the Annual Address by the President, Professor J. C. Nagle; "A Consideration of S. B. Buckley's 'North American Formicidæ,'" Dr. William Morton Wheeler; 'The Silt Problem in Connection with Irrigation Storage Reservoirs,' Professor J. C. Nagle; 'The Water Power of Texas,' Professor Thomas U. Taylor; 'Reptiles and Batrachians of McLennan County, Texas,' John K. Strecker,

Jr.; 'The Red Sandstone of Diabolo Mountains, Texas,' E. T. Dumble; 'Cretaceous and Later Rocks of Presidio and Brewster Counties,' E. T. Dumble; 'A Preliminary Report on the Austin Chalk Underlying Waco and the Adjoining Territory,' illustrated with half-tone engraving, John K. Prather; *Proceedings* of the Academy for 1901; List of Patrons and Fellows; List of Members; Constitution, in all covering 138 pages.

Frederic W. Simonds.
University of Texas.

DISCUSSION AND CORRESPONDENCE.

IRIDESCENT CLOUDS.

To the Editor of Science: The letter of Mr. Ward in Science of July 4, concerning iridescent clouds, leads me to record my observations of similar phenomena. From my own observations, covering five years in Princeton, Williamstown, Mass., and Baltimore, and seven years in Boulder and Denver, Colo., I am led to think that iridescent clouds are of very much more frequent occurrence in Colorado than in the Eastern States. And they occur much more frequently near the mountains than at a short distance out on the plains.

Boulder is situated immediately at the base of the eastern foothills of the Rocky Mountains, these foothills being from 1,200 to 3,000 feet higher than the plains, upon the edge of which the town is built. Just above these foothills a stratus cloud sometimes forms, especially in winter, whose lower edge is often bordered with a band of color, frequently very bright and clear. These colored bands occur from ten to twenty minutes after sunset. The cloud usually lies at a distance of 5° or 10° above the horizon and is often almost absolutely horizontal. The colors extend along the lower edge for a distance of 15° to 30°, being about 1° or 2° wide.

At other times I have seen great patches of cirrus clouds which were most beautifully iridescent. One of these I saw at about eleven o'clock which covered a space perhaps 5° or more each way and which was about 15° or 20° east of the sun. It lasted for ten or fifteen minutes, there being very little motion of the clouds on that day. At other times I have seen many small patches of color, mostly bluish-green and pink, appearing simultaneously in light cirrocumulus clouds. These usually occur about the middle of the afternoon. I have on a single occasion observed a similar effect produced by the full moon.

Denver is situated about twenty miles from the foothills. Although I have not kept a record, my observations during the last two years convince me that these cloud colors are seen much less frequently here than in Boulder.

I wish also to speak of a related phenomenon of very much less frequent occurrence. On July 5, I was looking toward a nimbus cloud from which the rain was apparently falling beyond a mesa which lies about five miles east of Boulder. It was between four and five o'clock in the afternoon. There appeared in the cloud a patch of rainbow colors about 10° long by half as wide. The colors were in the order of the rainbow, but the bands were very much broader and quite irregular. The colors lasted for ten or fifteen minutes. The position of the sun precluded the possibility of the colors being produced in the same way as in an ordinary rainbow.

I have but once before observed the same phenomenon. In the spring of 1895, I was teaching in Grand Junction, which is situated in the valley of the Grand River in the western part of the state. To the east of the town at a distance of about thirty miles the Grand Mesa rises to a height of 5,000 or 6,000 feet above the valley. On May 1, I observed a nimbus cloud, from which rain could be seen falling, lying in the eastern end of the valley and so low that the top of Grand Mesa could be seen above it. About half past three I saw in this cloud a strip of color extending north and south about 10° and about 5° wide. The red was above and about 10° or 12° from the earth. (These data are copied from my diary of that date.) The colors were quite as bright as in a brilliant rainbow and included all the colors of the rainbow. As in the former case, the position of the sun made it impossible to explain the production of the colors on the basis of the theory of the rainbow.

High School, Denver. E. Waite Elder.

PEAR BLIGHT IN CALIFORNIA.

THE discussion of California pear blight given in Mr. Webber's report of the proceedings of the Botanical Society of Washington,* induces me to offer some additional notes on this subject.

Although supposed cases of pear blight have been reported in California for many years, an examination of the affected orchards has always resulted, until recently, in throwing doubt upon the presence of that disease within the State. In the spring of 1899, however, there occurred a typical outbreak of blight in southern California, the malady assuming the normal epidemic form of spring development, spreading over several counties in a short time. This was the first case of the kind to come to my knowledge, although the orchards of the State had been under continual observation for upward of ten years previously.

As early as the spring of 1900 the disease developed seriously near Hanford and at other points in the southern half of the San Joaquin valley, while at present it has spread to a large percentage of the leading pear-growing districts of southern California and of the San Joaquin and Sacramento valleys. There are still special districts within the State which are wholly or nearly free from its ravages—as the Santa Clara valley and other coast regions.

The destructive development of pear blight in the hot interior valleys of California should at once dissipate the somewhat popular theory that bacterial and many other diseases of the East will not thrive under the semi-tropic and more arid conditions of portions of the Pacific coast. The facts are quite to the contrary. In California there is not alone a spring and summer, but likewise a fall and winter epidemic of pear blight, and the latter form of the disease is by far the more destructive manifestation of the two. The writer has given the name of 'winter blight' to the fall and winter type of the disease, and by careful inoculation experiments, conducted with pure cultures, has demonstrated the cause of winter blight to be identical with that of spring blight in the East.*

The leading characters distinguishing winter blight are: First, it rarely if ever attacks a tree at points higher than a man's head, always affecting the trunk or base of the main limbs, hence the larger and more vital portions of the tree; second, the infection takes place about the time the crop is gathered or shortly after; third, it continues in a most active and destructive state during the months of November, December and January; and, fourth, it may prevail in an orchard showing little or no signs of the spring form of the disease. The experience of growers supported by observation in the orchards shows that winter blight infections usually occur in short spurs developed upon the base of the main limbs or on the trunk of the trees. In California it is not uncommon for these spurs to develop clusters of flowers in the late fall, when the moisture rises in the soil or after the fall rains begin. The belated flowers rarely occur at points higher than a man's head, and they therefore serve as points of infection for the basal limbs and trunk of the trees. As the spurs are short the time required for the bacillus to pass from the flower to the parenchymatic tissues of the cortex of limb or trunk is brief, and the girdling of the trunk or main limbs is often a matter of a comparatively brief time. As the winter temperature of many California valleys is sufficiently warm to permit the blight bacillus to grow during November, December and January, and as the organism is so located in cases of winter blight that the affected parts cannot be removed by pruning without removing the more essential portions of the tree, the winter development of this disease has frequently resulted in more serious injury and greater losses of trees than the spring form of the malady in the East. In the latter form of the disease the twigs and smaller limbs are the leading points of infection, and a careful and early removal of the infected parts is commonly accomplished without serious injury to the trees.

In winter blight, as in spring blight, the

* SCIENCE, N. S., Vol. XV., pp. 989–991.

* See *California Fruit Grower*, May 4, 1901, Vol. XXVI., No. 675, p. 4.

growing tips of purely vegetative shoots occasionally serve as points of infection. Mr. Waite has said that 'it is only in the blossom blight that the honey bee is concerned,'* but Professor A. J. Cook has thrown a light upon this subject which suggests a need for further investigation. Professor Cook states that the bee men claim that the inoculation of pear flowers by means of bees 'cannot be the exclusive method of spreading this disease, as it often attacks and plays fearful havoc with nursery stock and young trees that have never blossomed at all.' To this Professor Cook replies that "It is well known that buds secrete a sort of glue for their protection in winter or spring. This attracts bees and other insects. The bees secure the main part of their bee glue or propolis from such resin-coated buds"; stating also that "it seems quite likely in such visits the bacteria are taken from diseased buds [or other sources of infection] and conveyed to healthy plants."† I would add to these views of Professor Cook that infection through growing buds of walnut branches is also of very common occurrence in the walnut bacteriosis caused by *Pseudomonas juglandis*.

This distribution of *Bacillus amylovorous* (Burrill) De Toni, through the agency of bees and other insects has been carefully demonstrated by Waite. The relation existing between the number of bee visits and the virulence of an epidemic of blight has, however, received less attention. Relative to this phase of the subject the writer has made several field observations having a direct bearing. A few miles north of Hanford, California, a large colony of bees was located within one fourth mile of two of the most valuable pear orchards of that region. These orchards were practically destroyed by blight before those more distant had become seriously affected. A second case of like nature was observed near Fowler and a third at Banning, California. The contrast between the number of infections in orchards near large colonies of bees and those more distant was very striking in both cases noted in the San Joaquin valley. The field conditions presented convincing evidence that near proximity of large colonies of bees to pear orchards greatly increases the danger to, and hastens the time of destruction of the latter.

* Paper read before the National Bee Keepers' Convention, Pan-American Exposition—printed in *California Cultivator*, Vol. XVIII., No. 25, pp. 390–391.

† *California Cultivator*, Vol. XVII., No. 6, pp. 83–84.

Newton B. Pierce.

Pacific Coast Laboratory,
Santa Ana, Cal.

THE ARC OF QUITO.

At a meeting of the Société de Géographie in Paris, France, on May 2, 1902, a communication was made to the Society by M. R. Bourgeois, Commandant du Service Géographique de l'Armée, Chef de la Mission française de l'Equateur, giving an account of the recent operations of the French Officers in remeasurement of the old arc of Peru now called the arc of the meridian of Quito.

An account of the reconnaissance for the extension and remeasurement of this arc can be found in Science for November 2, 1900.

The following is taken from *La Géographie*, the bulletin of the Société de Geographie for May 15, 1902.

As has been stated the reconnaissance was made in 1899. The time to complete the work was estimated at four years and in 1900, 500,000 francs (about $100,000) was appropriated for the field expenses.

The mission, composed of five officers, a military surgeon and seventeen non-commissioned officers and privates started to Equador in 1901 and began the work immediately after their arrival in June.

The first year's work has been completed, and M. Bourgeois has returned to France to report the progress made, leaving the Mission to continue the work under the direction of Captain Maurain.

The Mission reached Guayaquil June 1 with geodetic and astronomical instruments, camp outfit, baggage, etc., weighing 20,000 kilos (about 40,000 lbs.). This immense outfit was transported with difficulty to the scene of operations, and during 1901 the work was

extended over the region between Guayaquil and Riobamba, at the center of the valley region between the double range of the Andes which exists in this latitude, and the triangulation is now in progress in this valley region.

Three months were spent at Riobamba, and during this time the determination of the fundamental astronomical elements, longitude, latitude and azimuth were made and the fundamental base line was measured.

The base is ten kilometers long and two measures of the base were made in two and a half months with a resulting difference between them of seven millimeters. A four-meter bar was used in measuring this base.

After measuring the base the mission was divided into two parties, one of which continued the triangulation in the vicinity of Riobamba while the other proceeded to Quito for the purpose of measuring a base of verification and to determine the latitude of the northern extremity of the arc. One of the officers returned to Guayaquil and proceeded to Payta in Peru by sea in order to do similar work at the southern extremity of the arc.

The programme of the work for 1901 was successfully completed and the measurement of angles now in progress in the region to the north will be complete in 1902.

In 1903 and 1904 work in the region to the south between Riobamba and Peru will be completed and the measurement of an arc of the meridian six degrees in amplitude will be an accomplished fact with only a delay of four years, or within the time fixed in the beginning.

The difficulties are great as a description of the country shows; the altitude of the work is unusual, the resources are meager, the climate unfavorable and the means of communication very inadequate. Numerous vexations have been encountered, owing to the lack of intelligence in the inhabitants, such as the destruction of signals, the digging up of the marks, etc., but these are not of a nature to stop the observers before they have completed the work they have undertaken.

In conclusion M. Bourgeois expresses his pleasure in rendering homage before the Société Géographie to the knowledge and energy of his comrades, the officers of the mission, and also to the zeal and endurance of the non-commissioned officers and soldiers who accompany them, all of whom have exerted themselves to the utmost for the honor of French science.

I. W.

A FOSSIL MAN FROM KANSAS.

IN April of the present year, two young men living in the vicinity of Leavenworth, Kansas, in the excavation of a fruit storage cave near their residence, discovered a number of human bones. They paid but little attention to them, supposing them to be of little interest, but a brief reference to the discovery finding its way into the newspapers induced Mr. M. S. Long, the curator of the museum of Kansas City, a gentleman well known for his interest in, and as a collector of, things anthropological, to visit the locality. He recognized the scientific value of the find and secured such as remained of the bones discovered. Unfortunately, while the larger part of, if not the complete, skeleton had originally been present, many of the bones had been mutilated beyond repair or lost. A newspaper account of the find was widely published as that of a glacial man.

At the request of, and in company with, Mr. Long I have recently had the pleasure of making a careful examination of the locality whence the bones came, as also of the preserved remains themselves. This examination leads me to the firm conviction that the specimen is of great interest as representing the oldest reliable human remains hitherto discovered in North America. The reference of their age to the glacial period, though erroneous, was easily inferred from the presence of the characteristic glacial boulders lying on the side hill above the excavation.

The tunnel or cave excavated by the Concannon brothers is directed horizontally into the side of a hill to a distance of seventy-three feet, near the mouth of a small though deep ravine opening on the flood plain of the Missouri River, nineteen miles northwest of Kansas City, and within a few miles of Lansing, Kansas. The skeleton was found at the

extremity of the tunnel twenty-three feet from the surface above, as determined by a ventilating shaft dug near by. The floor of the tunnel is a heavy stratum of Carboniferous limestone six feet in thickness, that outcrops at its mouth. The material excavated, nearly uniform in all parts of the tunnel, is river loess or alluvium, interspersed here and there by limestone fragments. Some of these limestone masses are of considerable size and lie, for the most part, horizontally, as though they had fallen from a neighboring cliff and had been transported by the water. The material also contains numerous snail and some clam shells, the latter with the valves united. The alluvium is so firm and indurated that the tunnel, about eight feet in diameter, has retained its shape without any protecting props or walls, nor has there been any caving of its walls or roof. The skull and larger part of the skeleton was found irregularly placed, according to the testimony of the young men, near the bottom of the tunnel, the mandible separated some five or six feet. That the skeleton was intrusive, had been buried, or its position due to a creeping or sliding of the material, is inconceivable and out of the question. That there had been any deception on the part of the finders is equally inconceivable. I discovered fragments lying on the floor of the tunnel near the place ascribed to the discovery and picked up numerous other fragments on the dump outside, including a phalange and a complete os uncinatum. The bones were found where they were reported to be, and had been deposited there by the water, at or near the time of the person's death. The cranium itself contains positive evidence of its genuineness; not only is the characteristic matrix yet firmly attached to the bone, but indurated portions are included in its sinuses. The specimen is unquestionably a fossil and was found buried twenty-three feet below the present surface in indurated alluvium that has never been disturbed since its deposition. This alluvium is, moreover, of water deposition, and not æolian, or talus from the neighboring cliffs. Distinct lines of stratification are observed, one of them running clearly the whole length of the tunnel a little above the horizon of the skeleton.

The age of the skeleton is evidently post-glacial, but is nevertheless very great. Its horizon is about twenty feet above the highest water mark of the Missouri River and more than fifty feet above its present bed. Add to this at least twenty feet of river alluvium covering the fossil and we have evidence of a change of altitude in the Missouri River since the deposition of the fossil of at least forty and probably fifty feet. That is, the skeleton was deposited during the period of depression following the glacial epoch, during the time of the so-called *Equus* beds, the time of *Elephas, Mastodon,* extinct bisons, moose, camels, llamas and peccaries. I see no other possible conclusion to be drawn. I have examined the later Pleistocene deposits in Kansas in many places and have fossils of this sub-epoch from all parts of the state. I am confident that the Lansing man belongs in the same fauna.

Of the skull and other bones I will say little. I trust they may receive the attention of some professional ethnologist. Much credit is due Mr. Long for his appreciation of the value of the find, and for the care and infinite patience with which he has restored the badly mutilated cranium to its present satisfactory condition. The cranium appears to be of normal capacity, dolichocephalic, the forehead receding, the supraorbital and especially the supraciliary ridges prominent.

S. W. Williston.
Lawrence, Kansas, July 19, 1902.

PALEONTOLOGY AT THE AMERICAN MUSEUM OF NATURAL HISTORY.

The American Museum of Natural History has sent out four field parties, under the direction of Professor Osborn, for the collection of fossil vertebrates. Two of these are at present in Montana, one under Mr. Brown exploring the Laramie for horned Dinosaurs, the other under Dr. Matthew working farther west for Upper Miocene mammals. A third party under Mr. Granger has returned to the Como district of Wyoming and is working two quarries in that rich region; the Bone Cabin quarry is

still unexhausted, and promises to yield fine results again this season. A fourth party is working in western Nebraska especially for fossil horses, with the aid of the William C. Whitney Fund; this is the region where most of Leidy's classical types were found, and it is especially hoped to secure more material in order to determine the actual structure of these highly varied species of horses. In the museum the skeleton of the three-toed *Anchitherium,* secured by the Whitney exploration party last year, has recently been placed on exhibition, and will shortly be described in the Museum *Bulletin*. Professor E. C. Sterling has donated the fore and hind limbs of *Diprotodon* from Lake Callabona, Australia, with foot bones and casts sufficient to mount the feet of this enormous marsupial. From Moscow has been received through Mme. Pavlow a fine skull of the woolly rhinoceros, *R. tichorhinus*. Professor Koken, of Tübingen, has sent a series of casts of Triassic Dinosaurs. From Lyons, through Professor Charles Depéret, a beautiful series of original teeth of the genus *Lophiodon* has been received, chiefly Upper Eocene. Mr. Charles Knight has recently completed restorations of the *Ichthyosaurus* and a revised restoration of *Brontosaurus,* as well as of *Tylosaurus*.

SCIENTIFIC NOTES AND NEWS.

IT is announced that the President has designated Col. R. M. O'Reilly to be surgeon-general of the army to succeed General Forwood, who will retire on September 7 next. Colonel O'Reilly would hold the office for seven years before reaching the age limit.

DR. PASQUALE VILLARI has been elected president of the Accademia dei Lincei, Rome.

DR. J. G. GARSON has been appointed assistant general secretary of the British Association, succeeding the late Mr. G. Griffith.

WE regret to learn that Professor Virchow, who is now in the Hartz Mountains, is again confined to his bed, after having nearly recovered from his recent accident.

MR. J. E. SPURR, of the U. S. Geological Survey, who has for a year been engaged in surveys for the government of Turkey, has returned to the United States.

MR. H. W. TURNER has resigned his position in the U. S. Geological Survey to engage in practice as an expert in San Francisco.

PROFESSOR ALBERT VON KÖLLIKER, the eminent anatomist, has retired from the chair at the University of Würzburg, which he has held for thirty-five years.

DR. RITTER VON BASCH, professor of experimental pathology in the University of Vienna, recently celebrated the fortieth anniversary of his doctorate.

MR. PAUL DU CHAILLU is at present in Russia collecting materials for a book on the Russians.

WE learn from *Nature* that among the British civil list pensions announced in a parliamentary paper are the following: Mr. W. H. Hudson, in recognition of the originality of his writings on natural history, 150*l.*; the Rev. Dr. John Kerr, F.R.S., in recognition of his valuable discoveries in physical science, 100*l.*; Mrs. S. C. Jones, in recognition of the services rendered by her late husband, Principal John Viriamu Jones, to the cause of higher education in Wales, 75*l.*; and Mr. H. Ling Roth in consideration of his services to anthropology, 70*l.*

DR. CHARLES KENDALL ADAMS died at Redlands, Cal., on July 27. He was president of Cornell University from 1885 to 1892, when he resigned and became president of the University of Wisconsin. This post he held actively until 1901, when he retired on account of ill health. Since then he had lived in southern California, but the University had not accepted his resignation, and he was still president when he died. He was born at Derby, Vt., on January 24, 1835, and was graduated from the University of Michigan in 1861. Dr. Adams was the author of many works on historical and educational subjects, including 'Monarchy and Democracy in France' and 'A Manual of Historical Literature.'

MR. A. D. HOGG, who had been a botanical assistant to Professor Bayley Balfour in the University of Edinburgh, was drowned on July

first at the Gatty Marine Laboratory, St. Andrews.

We learn from *Nature* of the death of the Abbé Maze, on June 17, at the age of sixty-six years. He had been for many years one of the editors of *Cosmos*, the French weekly scientific journal; his first connection with that journal was as meteorologist after the Franco-Prussian War of 1870–1, and he was for some time secretary of the French Meteorological Society. About twenty years ago he undertook a laborious investigation into the periodicity of rainfall, which he has left uncompleted. He was also engaged for many years on a history of the thermometer, and has left in manuscript a large amount of information upon this subject.

We regret also to record the death of Dr. Förster, formerly professor of ophthalmology in Breslau; of Dr. W. Kiesselbach, professor of otology in the University of Erlangen; and of Louis Solignac, a French electrical engineer.

The American Medical Association will hold its next annual meeting from May 5–8, 1903.

The government of the Federated Malay States has established in Kuala Lumpur, the capital, a research institute which is under the direction of Hamilton Wright, M.D., of McGill University.

The new botanical laboratories of the Chelsea Physic Garden, London, were opened July 25.

A portfolio of twenty water colors depicting Indian life by the late Colonel Julian Scott of Plainfield, N. J., has been sold to the American Museum of Natural History. The pictures were painted from life while Colonel Scott was in Arizona in 1890 gathering material for the report on the eleventh census on the Indians in the Southwest.

Professor J. C. Merriam, head of the department of paleontology at the University of California, returned on the 26th from explorations in the Shasta fossil beds. Mr. Vance C. Osmont, an assistant in geology at the University, and Mr. Eustace Furlong, who were of Professor Merriam's party, have remained on the ground to make further investigations.

Nature, quoting the *Times*, states that the *Morning*, the auxiliary ship of the National Antarctic Expedition, sailed on July 9 for Lyttelton, New Zealand, *en route* to the Antarctic regions, where it is intended to meet the *Discovery* with supplies, and to render any other services which may be required. While the main object of the *Morning* is to act as tender to the *Discovery*, still she is well equipped with scientific instruments of various kinds, some of which have been supplied by the Admiralty, including survey instruments, a large photographic equipment, sounding gear, and apparatus for collecting at least the surface fauna of the ocean. Constant meteorological observations will be taken, and in other respects as far as possible the staff on board the *Morning* will do its best to supplement the work of the *Discovery*. The captain of the *Morning* and the commander of the relief expedition is Mr. William Colbeck, who was one of the staff of the *Southern Cross* Antarctic Expedition, on which he took the observations and drew the charts. The arrangements for the Scottish National Antarctic Expedition, under the leadership of Mr. W. S. Bruce, are making satisfactory progress. The Norwegian whaler *Hekla*, which Mr. Bruce recently purchased for the expedition, is to be renamed the *Scotia*. The ship is now being reconstructed on the Clyde, at Troon, by the Ailsa Shipbuilding Company, under the guidance of Mr. G. L. Watson, the well-known yacht designer. The *Scotia* is a barque-rigged auxiliary screw steamer of about 400 tons register. New deckhouses are being built, a larger one aft and a smaller one forward divided into a laboratory and cook's galley. A second laboratory and dark room is to be fitted between decks. The ship is being specially fitted to carry on oceanographical research, both physical and biological. Two drums, each containing 6,000 fathoms of cable, for trawling in the deepest parts of the Southern and Antarctic Oceans, are being taken. Mr. Bruce intends to follow the track of Weddell, working eastwards from the Falkland Islands.

The London *Times* states that the British Forestry Departmental Committee recently appointed by the President of the Board of Agri-

culture to inquire into and report as to the present position and future prospects of forestry in Great Britain, and to consider whether any measures might be taken, either by the provision of further educational facilities or otherwise, for its promotion and encouragement, has held its first sitting. Mr. R. C. Munro-Ferguson, M.P., was in the chair; and the other members of the committee were also present—viz., Sir John Rolleston, M.P., Mr. E. Stafford Howard, C.B., Dr. W. Schlich, C.I.E., F.R.S., Lieutenant-Colonel F. Bailey, Professor J. R. Campbell, Mr. J. Herbert Lewis, M.P., Mr. George Marshall and Dr. W. Somerville. The following witnesses gave evidence: Mr. Samuel Margerison (representing the Timber Trade Federation), Mr. Charles Hopton (vice-president of the Timber Trade Federation), Lieutenant-Colonel Bailey (Lecturer in Forestry at Edinburgh University), the Earl of Selborne, Sr. John Ramsden, Mr. Andrew Slater (Osborne), Mr. W. B. Havelock (Brocklesby, Lincs.), Mr. A. C. Forbes (Longleat, Wilts), Lord Glanusk, Mr. Donald Robertson (representing the Royal Scottish Arboricultural Society), Mr. John Davidson (secretary of the English Arboricultural Society), Mr. Arthur Vernon (High Wycombe), Dr. W. Schlich (principal professor of Forestry, Coopers-hill), Mr. Dudley W. Drummond (Ferryside, South Wales), Mr. Alexander Pitcaithley (Scone, Perthshire), and Mr. John H. Croxford (managing director of Messrs. Price, Walker and Co., timber importers, Gloucester).

MR. FRANK H. MASON, our Consul-General at Berlin, calls attention to the 'Motor-Boat' Exposition held at Berlin, during the present summer, and suggests that American makers are losing an opportunity where failing to exhibit. The excuse for not doing so, on the part of the majority of builders, is that they are too busy at home. Mr. Mason rejoins: "This may be true, but it is a fair question whether neglect to utilize an opportunity like this will not be a repetition of the mistake which the makers of fire-extinguishing apparatus committed, when they failed to exhibit at the special exposition of firemen's appliances held here last year. The one American firm which did exhibit an electric fire-alarm system is now putting it in for the city of Hanover, and has under negotiation contracts for similar installations in other German cities. There is abundant evidence that a good representative American display at the motor-boat exposition this year would be an unusually promising investment for the exhibitors. It is fully understood here that our country is first and foremost in all that relates to the construction and use of motor boats as naval auxiliaries and for pleasure and business purposes. It is also recognized that Germany—the original home of the gas engine—is so far behind in that class of water craft that the field is practically unoccupied. So many inquiries have been received by the committee about probable American exhibits —their tonnage, cost, and other details—that there is evidence of a real demand, and the committee states that from all such indications, American exhibitors of standard types of motor-boats, engines, etc., would be practically certain not only to sell their entire lists of exhibits, but to take numerous orders for future delivery. Responsible firms here and at the large German seaports are eager to accept agencies to represent American builders, and German machinists will be on the watch to purchase valuable patents in that class. Obviously, all novelties should be patented or registered and the patents applied for before being exhibited anywhere in Europe. It will be many years before another special international exhibition and classified competition of motor boats will be held in this country, and the present opportunity once lost will not soon recur. The committee authorizes the statement that every reasonable concession and assistance to facilitate a representative American display will be gladly and promptly accorded. Berlin is the center and mart of a vast system of canals, lakes, and canalized rivers which could be freely navigated by motor boats, where few or none now exist. If American builders will not reach out to grasp an opportunity like this, the builders of other countries—notably Great Britain, France, and Belgium—certainly will."

Word has been received from Mr. Alfred H. Brooks, geologist in charge of the work of exploration which the United States Geological Survey is conducting in Alaska, that his party has successfully crossed the Beluga River. This party recently landed in southern Alaska, and expects to penetrate the region in the vicinity of Mount McKinley as far as the Tanana River, whence they will proceed to Circle City and the Forty-mile district, if the season is not too far advanced, or will descend the Yukon River, of which the Tanana is the principal tributary on the south, if it is too late to go farther north. Much of the region through which they will pass is entirely unknown, and the Beluga River is supposed to be the greatest obstacle to progress. Mr. Brooks reports that with the aid of a boat he safely swam his entire outfit over this stream. He also reports that their first view of Mount McKinley was had from Mount Sushitna, a distance of 125 miles. Mount McKinley is the highest mountain on the North American continent—20,464 feet above sea level—and lies in the midst of an extremely rugged region which has never been explored.

On July 1 the Bureau of Forestry began its field season of 1902, and its work is now being carried on in 20 States. The Bureau has appointed 90 new student assistants for this season, the entire field force numbering 165 men. The work includes, among other things, the gathering of the necessary data for several working plans, a study of a number of well-known commercial trees, the examination of farm woodlots, and a study of the treeless areas with a view of devising plans for forest extension. The Bureau of Forestry begins the new fiscal year of 1902–1903 with an appropriation of $291,860. The amount for the year just ended was $185,440. The present season's work is being carried on in Maine, New Hampshire, Vermont, Massachusetts, New York, New Jersey, Maryland, Tennessee, Kentucky, West Virginia, North Carolina, Michigan, Minnesota, Nebraska, Oklahoma, South Dakota, Montana, Arizona, and California. Later in the season it will be extended to still other States and Territories.

UNIVERSITY AND EDUCATIONAL NEWS.

On the occasion of the celebration of the centenary of the Technical Institute at Charlottenburg, the sum of about $450,000 was collected by subscription. $12,000 is to be spent for a monument commemorating the centenary and the balance is to be used as a fund for the advancement of technical science. It is administered by a board of twenty-five members.

Mr. Orsen V. Tousley has bequeathed $70,000 to Williams College, subject to a life interest of his wife. He suggests that the money be used as an endowment for the purchase of books.

Dr. Charles R. Keyes, the geologist, has been elected president of the New Mexico School of Mines.

Mr. W. A. Hamilton, graduate of the Indiana University, has been appointed professor of astronomy and mathematics at Beloit College.

It is reported that all appointments for the newly organized collegiate department of Clark University have now been made. Professors Story (mathematics), Webster (physics) and Hodge (biology), of the University, will have charge of the same departments in the college. Mr. J. G. Coffin, B.S. (Mass. Inst.), is to be instructor in physics; Mr. C. W. Easley, A.M. (Dickinson College), instructor in chemistry; and F. H. Hodge, A.M. (Boston), instructor in mathematics. These instructors hold appointments as fellows in Clark University for the coming year. Instructors in modern languages, in English and in economics and history have also been appointed; and, as we have already announced, Mr. R. C. Bentley, fellow in pedagogy, has been appointed professor of Latin and Greek and dean of the faculty.

Professor E. E. Bogue has been elected to the chair of forestry in the Michigan Agricultural College.

At the University of Vienna Dr. Carl Gussenbauer, professor of surgery, has been appointed rector and Dr. Ernst Ludwig, professor of chemistry, dean.